# Discovery

NOVEMBER 1953 1/6

MONTHLY NOTEBOOK
Reliability of Intelligence Measurements
Per Ardua ad Astra
Antibiotics and Cancer
More Food from the Sea

PLANT HORMONES
Prof. S. C. Harland
*F.R.S.*

AUTOMOBILE DEVELOPMENT
W. Harold Johnson

PALLADIUM AND ITS ANONYMOUS DISCOVERER
A. K. Parker
*M.A.*

MALTHUS AND THE SCIENTISTS
Arthur Marsh
*M.A.*

ELECTRONIC-FLASH PHOTOMICROGRAPHY
Douglas P. Wilson
*D.Sc, F.R.P.S.*

CHARLES STANHOPE (1753-1816)

FAR & NEAR

BOOKSHELF

A range of platinum apparatus as shown at the Platinum Metals Exhibition. See p. 344.

# Memory Unlimited

I JUMPED into the first railway compartment which seemed empty: my eyes fell on a book left on the seat opposite by a previous passenger.

I took it up absent-mindedly and ran through the first lines. Five minutes later I was reading it as eagerly as a clue to a hidden treasure. I learned that everyone's memory is capable of fantastic feats; that an ordinary person if he has taught himself to control the way in which his brain stores impressions can memorise accurately long and complicated lists of facts after reading them over only once or twice. I thought I would test the truth of the statement.

I took a timetable out of my suitcase and began reading quietly in the manner prescribed, the names of about one hundred railway stations. I observed that after reading them over a few times I could recite the whole list off with hardly a mistake. With a little more practice I found I had committed them so completely to memory that I could remember them in the reverse order and even pick out one station from the list and say which number it was, and what were the names of the towns before and after it.

I was astonished at the memory I had acquired and spent the rest of my journey on more and more difficult experiments in memory, and reflecting how this new control I was achieving over my mind would materially help me to a greater success in life. After this, I worked hard at this wonderful memory system, and within a week I found I could recall passages from books and quote them with ease: names, addresses and business appointments were remembered immediately; and in four months I had succeeded in learning Spanish.

If I have obtained from life a measure of wealth and happiness, it is to that book I owe it, for it revealed to me the workings of my brain.

Three years ago, I had the good fortune to meet its author, and I promised him to propagate his method, and today I am glad of this opportunity of expressing my gratitude to him.

I can only suppose that others wish to acquire what is, after all, the most valuable asset towards success in life.

Borg's address is: **S. A. Borg, c/o Aubanel Publishers, 14 Lower Baggot Street, Dublin**. Apply to him for his little book, "The Eternal Laws of Success". It is free to all who wish to develop their memory.

F. ROBERTS.


*GOVERNMENT PUBLICATIONS*

## RADIOISOTOPE TECHNIQUES

THE record of the proceedings of the Isotope Techniques Conference, held in Oxford in July 1951, sponsored by the Atomic Energy Research Establishment. These two volumes give in full the 98 papers which were presented together with a brief account of the discussions following each paper.

VOLUME I. Medical and Physiological Applications 50s. (50s. 8d.)

VOLUME II. Industrial and Allied Research Applications 25s. (25s. 4d.)

*Prices in brackets include postage*

HER MAJESTY'S STATIONERY OFFICE

York House, Kingsway, London, W.C.2; 423 Oxford Street, London, W.1 (Post Orders: P.O. Box No. 569, London, S.E.1); 13a Castle Street, Edinburgh, 2; 39 King Street, Manchester, 2; 2 Edmund Street, Birmingham, 3; 1 St. Andrew's Crescent, Cardiff; Tower Lane, Bristol, 1; 80 Chichester Street, Belfast; or through any bookseller.

*Telephone*: **EUSton 4282**

## BOOKS

LARGE STOCK OF NEW & STANDARD BOOKS ON CHEMISTRY—PURE AND APPLIED, PHYSICS, MATHEMATICS, BIOLOGY, PSYCHOLOGY, ENGINEERING, AGRICULTURE. STUDENTS' TEXT-BOOKS FOR ALL SCIENTIFIC EXAMINATIONS SUPPLIED. CATALOGUE ON REQUEST

*Please state interests when writing*

## SCIENTIFIC LENDING LIBRARY

**Annual Subscription from 25 shillings**

The library covers a wide range of subjects and is invaluable to schoolmasters and students.

*Prospectus free on request*

**THE LIBRARY CATALOGUE** revised to December, 1949, containing a classified index of authors and subjects. Pp. xii + 1152. To subscribers 17s. 6d. net. To non-subscribers 35s., postage 1s. 3d. Supplement 1950 to 1952. To subscribers 3s. net; to non-subscribers 6s. net; postage 6d.

## SECOND-HAND BOOKS

Large stocks of recent editions of scientific and technical works available

**Libraries or small collections purchased**

LONDON

**H. K. LEWIS & Co. Ltd.**

136, GOWER STREET, W.C.1

# Discovery

THE MAGAZINE OF SCIENTIFIC PROGRESS

*Editor* WILLIAM E. DICK *B.Sc, F.L.S.* *Editorial Office* 244 High Holborn, WC1 *Telephone* Chancery 6518
*All subscriptions, distribution and business communications to* Jarrold & Sons Ltd, Norwich *Telephone* Norwich 25261
*Subscription Rates Inland and Overseas* 6 months 9s, 12 months 18s *U.S.A.* 6 months $1.50, 12 months $3
*Advertisement Office* Aldridge Press Ltd, 15 Charterhouse Street, EC1 *Telephone* Holborn 8655

NOVEMBER 1953 VOLUME XIV NUMBER 11


# THE PROGRESS OF SCIENCE

## THE RELIABILITY OF INTELLIGENCE MEASUREMENTS

At the Liverpool meeting of the British Association Dr. J. D. Nisbet of Aberdeen University read a paper in which he described the results of following up the academic and professional careers of students who had taken intelligence tests. The facts in this paper will doubtless provide still more ammunition for use in the continuing warfare waged between those who believe in psychological measurement and those who do not.

The world of psychologists is indeed rife with controversies, a fact that is understandable because of the great complexity of animal behaviour. This complexity makes reliable experimentation onerous and unexceptionable conclusions very difficult; it makes measurement in the sense that the exact scientist understands it impossible. Yet measurement, which marks the transition from the qualitative to the quantitative, is the most generally satisfactory device for the attainment of accuracy and objectivity in description. So ever since Fechner formulated his psycho-physical laws more than a century ago there have been psychologists who have continued the search for methods and criteria of psychological measurement, a search greatly aided by statistical techniques, which were first used in anthropological studies by the Belgian mathematician Quetelet.

One of the many human attributes so far subjected to measurement is that called 'intelligence'. This is no place to delve into the difficulties of defining this quality; suffice it to say that everyone faced with a statement such as *X is more intelligent than Y* has a very fair idea of what is meant. It does not mean that X has more intellectual tastes than Y or is aesthetically more sensitive than Y or will achieve better results than Y in a prolonged piece of work. It *does* indicate that X is better than Y at relating facts of experience, at grasping the set-up of a new environment, at spotting patterns of thought or behaviour. In ordinary language, X is *brighter* than Y.

The founder of the quantitative study of intelligence was the Frenchman, Alfred Binet. In 1900 the school authorities of Paris, disturbed at what they considered the low standard of achievement in the schools, wished to find out what this was due to. Clearly, if there was some way of estimating a child's capacity for learning, this would help in solving the problem of poor achievement. Binet, helped by being the father of two girls whom he could observe at close hand, set out to find such a way. He and his assistant, Simon, established the *Binet-Simon intelligence tests*. These tests, later modified and amplified by Terman and Merrill in America, are still the most widely used of all intelligence tests.

Binet went further; he invented a parameter called the *Intelligence Quotient* or *I.Q.* Its calculation is simple. Binet devised a batch of tests on which he found the majority of 7-year-olds could score full marks, another batch for 8-year-olds, and so on. A child who could score on all the 8-year-old tests and on none of the 9-year-old tests would have a 'mental' age of 8 years. (In practice such a simple demarcation between the years is almost unknown; instead methods of calculation are used which bring in fractions of a year.) A boy nine years old who has a mental age of eight is said to have an I.Q. of 8/9 or about 90%.

Tests applied to large samples of population give results that show a normal distribution of I.Q., the majority having an I.Q. of 100, somewhat fewer having an I.Q. of 90 or 110, still fewer with an I.Q. of 80 or 120, and so on. The fact that such a normal distribution exists is one statistical justification for the methods used. (It is worth remembering that intelligence tests for, say, 8-year-olds are not a backroom invention designed to indicate what tests 8-year-olds *ought* to be able to pass, but are the results

of tests already made showing that this particular batch of tests is the one that the majority of 8-year-olds *can* pass, other things being equal.)

The Binet-Simon tests are applied individually. Another well-known set of tests is applied to groups—the Otis tests. Group tests are used in the Services. All these involve some verbal skill. There are others that evade any demands on literacy, such as the Raven Matrices test, doubtless remembered by many ex-servicemen. Results for all these tests can be transmuted into I.Q.

There has been plenty of criticism of intelligence tests, ranging from criticisms that are silly and trivial to those that are serious and informed, but by and large the tests have stood the test of critical examination. The I.Q., *if* it is obtained from tests correctly made with both the examiner and examinee doing their best, is a useful parameter, an indication of mental ability in the general sense—*of general intelligence*. Moreover, it varies very little for any one person, whether he is sick or well, and is not affected by a change of environment, or by the fact of growing older. A pupil who at nine years of age has an I.Q. of 120 will have an I.Q. ranging in the extreme between 112 and 128 for the rest of his life except for a slight decline with the later years. Furthermore it is now agreed by the leading authorities that about 80% of the I.Q. is due to innate, inherited factors.

This being accepted, what relation has a person's I.Q. to his achievement in life? Obviously, brightness is only one of the many attributes of human personality, all of which can infringe upon and modify the factor of brightness. Nevertheless it has frequently been remarked by educators that a high general intelligence is the common factor among people with high attainment in work involving the intellect (though this does not apply to work involving a specialised manual skill). Many Service educators have noted this fact. For example, in the training of radar mechanics who started from scratch, the men with high intelligence quotients did best, men who had been in civilian life bank clerks, schoolteachers, and the like. In some civilian establishments where such men were trained it was customary to give some sort of modified intelligence test to new entrants, and the correlation between the results of such tests and the results of the course examination was always positive and high.

Dr. J. D. Nisbet provided more exact evidence for this same thesis. 222 students, training to be teachers, sat for a 45-minute intelligence test in the early 1930's. Their degree achievements and their careers have been followed up and analysed statistically, and there is no doubt that high scorers in the test have on the whole done much better than the low scorers.

To illustrate this conclusion Dr. Nisbet considered two sample groups, one containing 18 high scorers and the other containing 15 low scorers. Of the 18 high scorers, 12 took their M.A. degree with honours, 2 took the double M.A.-B.Sc. degree, and the remaining 4 took ordinary degrees. Not one of this group got the bare minimum pass marks. Today, of the 11 still in the teaching profession, 8 are in positions of responsibility.

The record of the 15 low scorers is very different. One gained second-class honours in his degree, and another gained third-class honours. The remaining 13 all took ordinary degrees, 8 of them just scraping through. Today, of the 9 who can be traced only 4 are still teaching. Only one of these is in a post of responsibility.

These results indicate not only that the I.Q. has considerable reliability as a predictor of achievement but—what is just as important—it is not a *certain* predictor, which is after all what one would expect.

## PER ARDUA AD ASTRA

The fourth Anglo-American Aeronautical conference (convened by Britain's Royal Aeronautical Society and the American Institute of the Aeronautical Sciences) was recently held in London. As the biggest customers of the aeronautics industry are the Services, and as aeronautical development is so largely tied up with military needs, it was not surprising to find that many current research items could not be discussed. Nevertheless some interesting papers were presented, and the meeting also provided valuable opportunities for informal discussions between individuals outside the conference room.

On the structural side the problems which seemed most pressing were those connected with the so-called 'thermal barrier' and fatigue. Heating of the aircraft structure is caused by the considerable aerodynamic friction which occurs at supersonic speeds, and this leads to a direct reduction in the strength of conventional structural materials. Heat also affects the aerodynamic contours of aircraft.

Some speakers suggested that it was over-optimistic to suppose that titanium alloys would provide the solution to these troubles, though it must be recognised that development work on these alloys is at a very primitive stage—it is really far too early to form any useful judgment as to their performance under prolonged operational conditions. Other methods of circumventing the difficulties are receiving attention, as for instance the use of artificial cooling to keep the temperature of aircraft structures down to levels at which the maximum possible strength is maintained.

One American speaker said that in the United States there was a conviction that nuclear power units for aircraft come within the realm of practical possibility, though new structural materials (he mentioned fibre glass among other things) would have to be used in connexion with such engines, and new design concepts would be needed.

Another significant trend in the American aircraft industry is the use of various punch-card systems and electronic analogue machines for computational work. These make it possible to use as a matter of routine technical methods previously out of the question because of the sheer mass of intricate calculations they involved. These computations can now be carried out with great speed and accuracy on the various machines available. The limiting factor now is the difficulty of finding the people to 'programme' the machines, a skilled job which seems to call for some special aptitude as well as special training. (The basic principles of programming may be learnt inside three months or so, but not everyone who is trained is capable of working out the ideal programme for a particular job. The designing of a good programme

calls for qualities similar to those which lead to the perfect solution of a particular mathematical problem.)

Fatigue of aeroplane structures was reviewed by a spokesman of the U.S. National Advisory Committee for Aeronautics, who explained that special interest in fatigue phenomena had been aroused by two crashes, one of a U.S. aircraft in 1948 which was followed by a British crash in 1951, that were ascribed to a major fatigue failure of the primary wing structure. The repeated loads caused by gusts of wind are held to be responsible. The trouble starts with a fatigue crack, which grows and grows without being detected, until finally the structure fractures. Sudden disastrous failure of this type was the central technical theme of Nevil Shute's famous novel *No Highway*, which has undoubtedly stirred the imagination of aircraft experts in such a way that foresight with regard to remote fatigue troubles is encouraged. This keen concern with fatigue compensates for the pressure exerted by the apparently insatiable demand for minimum weight in aircraft structures. There is enormous scope for further research into the fatigue properties of materials, and it is now an axiom of the industry that static strength is not necessarily any index of strength when the structure is subjected to rapidly fluctuating loads. It is hoped that the study of solid state physics at the molecular level will shed light on some fatigue phenomena.

Dr. de Bruyne of Aero Research (which is now controlled by Ciba) gave an interesting paper about the application of adhesives in metal aircraft construction, a field in which he is a pioneer. These bonded metal structures have many advantageous qualities; weight is reduced, the external finish is smooth (because of the absence of rivet heads), and production time and costs are kept down. The technique makes practicable new types of structure, such as 'sandwich skins', in which metal panels are glued on to each side of a honeycomb filler of foamed plastic. Many firms in Britain and the U.S.A. are exploring the tremendous potentialities of metal gluing. The Comet is a notable example of the use of Dr. de Bruyne's 'Redux' process. One special use of this type of bonding is the construction of metal rotor blades for helicopters, which are very difficult to build by conventional spar and riveted skin methods.

A paper indicative of the divergence of opinion between the British and American ideas on multi-jet aircraft described the pod mounting of jet engines. In Britain we have taken fullest advantage of the disappearance of propellers by burying the jet engines in the wing in the thickened root sections, which accounts for the very clean appearance of the Valiant or Vulcan, for example. The Americans, on the other hand, have chosen to hang their engines in 'pods' below the wing on their multi-engined types. Schairer, of Boeing, strenuously argued the case for 'pods', but to British experts he must have appeared to be flogging a dead horse. Some of his points in favour of external mounting (e.g. increased safety if the turbine wheel shatters explosively, and the ease of increasing the number of engines or installing more powerful engines) do not seem to apply in Britain. It will be interesting to see whether the criticisms of pod mountings by some of our leading designers who discussed this paper will have any influence on future American designs.

Only one paper was directly concerned with aerodynamics. This covered some recent work carried out at Princeton University on the control of the boundary layer. Much attention has recently been given to the use of suction on an aerofoil surface (either through slots or through a porous surface) for the purpose of keeping the boundary layer—which is the thin layer of air close to the surface—from breaking away. The novelty of the Princeton experiments lies in the use of a suction slot at the *trailing edge* of the aerofoil, in contrast to the familiar work where the slot is located near the leading edge. While control of the boundary layer dangles a most attractive carrot just in front of the aircraft designer's nose, for it promises reduced drag and increased lift and hence reduced landing speed, the practical problems of applying it to an actual aircraft wing, in contrast to trials confined to models in wind tunnels, are bound to be enormous. The discussion showed very clearly that designers have mixed feelings about using boundary layer control in practical flight.

The last paper of the conference was well chosen from the British point of view, for it was presented by the Operations Director of B.O.A.C. and dealt with the introduction of the Comet into service, a major landmark in the conquest of the air. This plane was the world's first jet air liner and gave this country a clear lead over all rivals. America, for instance, still has no form of jet transport plane.

## ANTIBIOTICS AND CANCER

'*ANTIBIOTIC*' means 'against life'. The class of drugs called antibiotics are so named because they function against the life of disease-causing micro-organisms. Now comes a muted, tentative hope they may function against yet another pathogenic life process—the proliferation of cancerous cells.

This item of news was quietly dropped by Nobel prize-winner and antibiotics-pioneer Dr. Selman A. Waksman at the recent International Congress for Microbiology in Rome. It landed with the gentle thud of an atomic bomb! For a cancer-conscious world any promise, no matter how faint or remote, of a cancer cure becomes a rallying point of faith and hope.

Afterwards, in his suite in the luxurious Excelsior Hotel, Waksman was inundated by personal callers, phone calls and telegrams. Journalists, emissaries of Oriental potentates and Occidental diplomats jostled each other in their clamour for more information about this potentially life-saving discovery. Amid them a lone English father came in the hope that here he would find a cure for a young daughter who was dying of leukemia.

What are the facts behind the remark which set off this furore? Their foundation was laid some thirteen years ago—by Dr. Waksman himself. In 1940, when the success of penicillin had set a war-torn civilisation on a frantic search of new antibiotics to fight the germs which thrive in the wake of battle, Dr. Waksman isolated the very first antibiotic to be derived from the class of mould-like bacteria called the Actinomycetes. He called this substance *actinomycin*, which is a metabolic product of *Streptomyces antibioticus*.

Actinomycin would kill germs all right—but it had one great disadvantage. It was almost as toxic towards laboratory animals as it was towards germs. Especially it played havoc with their lymphatic tissues; thus, for example, the spleen of animals receiving actinomycin contracted to half its normal size.

This was an interesting observation, but time was pressing, actinomycin was toxic, and other, more promising, antibiotic germ-killers were waiting to be discovered. So Dr. Waksman put actinomycin to one side and pushed on with his researches. Three years and two antibiotics later his efforts were crowned with success. He found streptomycin, the antibiotic produced by cultures of *Streptomyces griseus*.

But his observations on the antagonism of actinomycin towards lymph tissue did not go unnoticed. In post-war Germany, it occurred to Dr. Christian Hackmann, who was working in the laboratory of Dr. Gerhard Domagk (whose discovery of the chemotherapeutic effect of sulphanilamide won him a Nobel Prize in 1939) at Elberfeld in the Ruhr, came the thought that perhaps actinomycin might be even more toxic to wildly growing cancer cells than to normal tissue cells.

He set to work to test his idea on cancers of rats and other laboratory animals. The results were promising. Of four hundred preparations he tested one in particular, actinomycin C*, stood out. In doses too minute to cause toxic symptoms in the animals, it seemed capable of inhibiting the growth of some cancers. Against lymphatic-type cells it was especially potent.

This was the signal for a trial of actinomycin C in humans. Dr. Hackmann enlisted the cooperation of Prof. Dr. Gustav Schulte, director of a Recklinghausen hospital. Carefully choosing cancer patients in whom all else had failed, Dr. Schulte cautiously injected infinitesimal doses—measured in terms of *micro*grams—of actinomycin C.

In the course of the two ensuing years Dr. Schulte treated 150 patients with varying types of cancers. In most of them he noted improvement in appetite, spirits and weight under actinomycin therapy, but only in one particular type of 'cancer'—namely, Hodgkin's disease—did the growths themselves regress. Hodgkin's disease is characterised by marked enlargement of lymph nodes. Sometimes they reach the size of a fist. In six patients treated with actinomycin alone, Dr. Schulte brought the glands back to normal size. Today, about two years later, these patients have still not relapsed, though three critical years lie ahead before a cautious 'cure' can be pronounced.

There is no doubt this discovery has the profoundest significance, but not that proclaimed in some quarters. One commentator in the popular press attributes to this inhibition of cancer by an antibiotic support for the germ theory of cancer causation. He loses sight of the fact that the underlying principle, which touched off this line of research, was the toxic effect of actinomycin against normal lymphatic tissues, as observed by Dr. Waksman.

This same commentator also concludes that the specific action of actinomycin against enlarged lymph nodes in Hodgkin's disease will make it invaluable in attacking secondary cancer growths which have spread to the regional lymph nodes from a primary growth. This, too, is fallacious reasoning. The secondary growths are of the same kind of cancer tissue as the primary tumour and, therefore, no more susceptible to actinomycin than the original cancer.

The true significance of the German discovery is pointed out by Dr. Waksman himself. Of 105 antibiotics so far isolated from the Actinomycetes only about 10 have found clinical use against infectious diseases. The discovery that an antibiotic discarded as too toxic for the treatment of bacterial infections is none the less valuable in the control of certain types of tumours, opens up the possibility that among the other 90-odd discarded antibiotics may be some with similar anti-cancer action.

Dr. Waksman says he is now turning back to his laboratory bench for a complete re-assessment of these Cinderella antibiotics.

Readers will recall that way back in 1944 the antibiotic called *patulin* (a metabolic product of several moulds including *Penicillium claviforme*, *P. patulum* and *Aspergillus clavatus*) proved to be more toxic towards leucocytes and other mammalian body-tissues than it was towards bacteria. This clue was followed up by two German scientists, Dr. Hildegard Vollmar and Dr. Moll, who found that it stopped the growth of normal skin tissue cultivated outside the body and also upset the mobility of leucocytes. A similar effect was found when patulin (at concentrations of 1: 25,000 and 1: 50,000) was tested on malignant tissues.

* There are several chemical variants of actinomycin. These are lettered alphabetically, beginning with Dr. Waksman's actinomycin A.

REFERENCES

Hackmann, C., "HBF 386 (Actinomycin C), ein cytostatisch wirksamer Naturstoff", *Strahlentherapie*, 1953, **90**, 296.

Schulte, G., "Erfahrungen mit neuen cytostatischen Mitteln bei Hämoblastosen und Carcinomen und bei Abgrenzung ihrer Wirkung gegen Röntgentherapie." *Zeitschrift für Krebsforschung*, 1952, **58**, 500

The patulin work of Dr. Vollmar and Dr. Moll was briefly described in DISCOVERY, January 1949, p. 1.

## MORE FOOD FROM THE SEA

The world's ever increasing population demands more and more food. Production on land is being stepped up to meet this need, though it is increasing far too slowly if reasonable nutritional standards are to be secured in all countries. The harvest from the sea could also be increased more rapidly than it is at present, and this fact was strongly brought out by the autumn conference held in London by the Institute of Biology, the up and coming body which aims to do for biology what the Royal Institute of Chemistry does for chemistry. The vast food potentialities of the sea were discussed by experts, who showed their eagerness to contribute their share to the fuller exploitation of the world resources of marine foods.

At the British Association meeting at Liverpool some of the new scientific aids to fishery development were described, one of which—the echo sounder—is already being exploited effectively. It was mentioned at Liverpool that the Norwegians have opened up vast new fishing grounds which they discovered using this apparatus,

now almost standard equipment on all Norwegian fishing boats. The practical importance of this apparatus both for finding new fishing grounds and for increasing the efficiency of fishing operations in general was again stressed by the London conference. Dr. G. A. Steven of Plymouth, for example, showed some slides that demonstrated very plainly how the echo sounder can even be used to identify the kind of fish in a particular shoal. Herring, for instance, give a quite different record from mackerel or sprats.

There is no doubt that the new apparatus makes it possible to investigate problems of underwater biology which were literally beyond reach until recently. The underwater camera developed at Plymouth by Dr. H. G. Vevers is an example, and already new scientific facts about the population density of bottom-living animals are being collected. This type of information is at present mainly of academic interest, but it is just the kind of information which can later be applied to the solution of practical fishery problems.

Until recently it was extremely difficult to give any useful estimate of the amount of photosynthesis carried on by marine plants. Now a new method of estimating this has been devised by Prof. Steeman Nielsen, who has used it with data which was collected during the expedition of the Danish research ship *Galathea*. This method is a tracer method, and follows the fate of radioactive carbon (carbon 14) when carbon dioxide is fixed by plankton algae. The rate at which carbon is fixed per cubic metre of sea water can thus be measured. It is known that all the useful photosynthesis occurs in the top hundred metres of the sea, and therefore it is possible to calculate the total amount of carbon which is fixed in the oceans. The professor's figure works out at $1{\cdot}5 \times 10^{10}$ tons of carbon per year, which is about the same as the total amount of carbon fixed by the terrestrial vegetation of the world. The figure, of course, is only a rough approximation, and it should be noted that other scientists have given estimates up to *ten times* as large as Prof. Nielsen's.

For the English Channel it is calculated that the plant crop each year is about 2–3 tons per acre, comparable to the yield for, say, an acre of wheat. The average yield per acre is higher in the North Sea, and may be as much as twice as big. That for Antarctic waters can be very much higher, according to Dr. C. E. Lucas. Tropical waters on the other hand carry relatively poor crops.

Ideas about the capacity of algae to synthesise foodstuffs are now being clarified as data accumulate from current experiments that are being made with pure cultures of a particular unicellular alga called *Chlorella*. This microscopic green alga multiplies at a tremendous rate when it is grown under good conditions in tanks of nutrient solution. The *Chlorella* crop is harvested by means of a centrifuge, and chemical analysis of the resultant green powder suggests that it should have a high nutritive value and that it should make a useful feeding-stuff at least for farm animals. We have ourselves tasted samples of this centrifuged powder, and though we should not give it high marks for either flavour or texture, we hasten to add that it bears comparison with some samples of dehydrated vegetables we have tried.

These *Chlorella* investigations, which are being vigorously pursued in both Britain and America, stemmed from the suggestion of two Americans, H. A. Spoehr and H. W. Milner, that *Chlorella* might be grown on an industrial scale to supplement supplies of fat. Readers will find that a great deal of information about the performance of *Chlorella* is summarised by Dr. G. E. Fogg in his most valuable book, *The Metabolism of Algae*, just published in the series of Methuen's biological monographs (150 pp., 8*s*. 6*d*.).

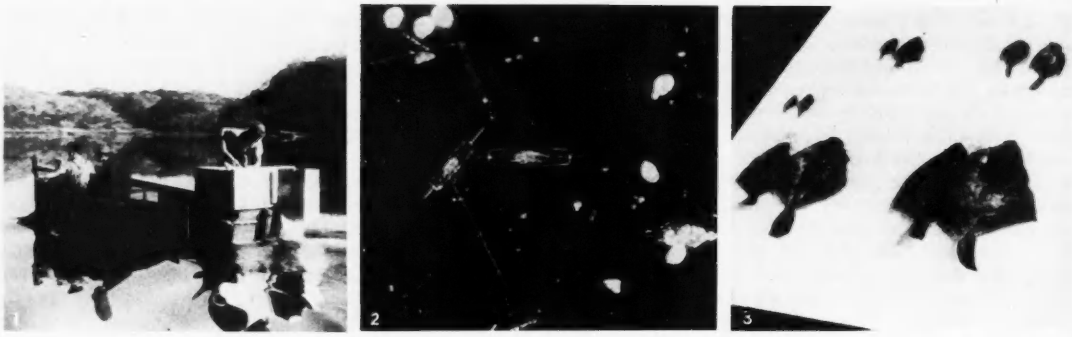
*Some idea of the possible significance of this proposal can be gained by considering the full implications of the statement that two million acres of culture tanks growing Chlorella under ideal conditions could supply all the protein needs of the entire world.*

These investigations have had the effect of giving a fillip to another idea—the proposal to harvest marine plankton and use it directly as food. Behind this proposal lies the same sort of argument which justifies the work on leaf protein which we discussed in the July 1953 issue of DISCOVERY (pp. 199–200)—the argument that we ought to try to tap directly the nutriment present in vegetation instead of relying on browsing animals to convert the plant foods into animal protein which we then eat. The latter way of using plants is inefficient, it is said, though this line of argument rather ignores the fact that food must not only be nutritious but also palatable and digestible. Many people have, of course, tried eating plankton and there is one passage in *Kon-Tiki* about the mixed reactions of Heyerdahl and colleagues to one such experiment. There is no doubt that the nutritive value of plankton must be high, judging from the way that many fish thrive on it and most species of whales support their vast bulk on a diet composed entirely of pure plankton.

For research purposes scientists have devised effective equipment for 'straining' the plankton from sea water. But their plankton nets and plankton samplers are essentially research tools, and their performance has little bearing upon the idea of collecting plankton on a large scale for use as food, though perhaps Prof. A. C. Hardy's continuous plankton recorder might form the basis of a commercial method of collecting both zooplankton and phytoplankton. The idea has been taken a stage further by a chemical engineer named Shropshire who has developed a technique for concentrating plankton. He separates the plankton organisms by pumping large quantities of water through a rotary drum filter; in this the filter mechanism, which depends on the sieving action of bolting cloth with 150 meshes per inch, retains the organisms which are then dislodged and removed continuously and automatically. Shropshire's rotary drum filter is quite compact—the drum is 8 ft. in diameter and 16 ft. long—and quite efficient. It can handle 25,000 gallons a minute, and is capable of collecting nearly half a ton of plankton a day.

These facts about the extraction of plankton were presented by Dr. C. E. Lucas of the Marine Laboratory, Aberdeen, who was careful to stress that the harvesting of phytoplankton at an economical rate is not just around the corner. But, as Dr. Lucas said, the possibility of harvesting it does not appear quite so fantastic today as it used to.

Increasing the fertility of the sea by the addition of



THE LOCH SWEEN EXPERIMENTS. (1) The fertilisers are shovelled out of the large box at the stern of the motor boat and are spread by the wake. (2) First to benefit from the extra supply of mineral salts are the microscopic plants—the phytoplankton, of which a sample is shown here. Then comes an increase in the abundance of planktonic animals—the zooplankton, as it is called. (3) Next the bottom-living animals such as marine worms and shellfish increase in number, and finally the fish benefit, reaching maturity faster and breeding more rapidly. This picture shows the striking difference between plaice from fertilised areas of the loch (*bottom row*) and from unfertilised areas (*top row*). The two groups shown are respectively 12 and 18 months old; the two tiny fish on the left show the size of the fish when this particular experiment was begun.

artificial fertilisers has been tried out on a fairly large scale. Readers will recall Dr. D. T. Gauld's account (DISCOVERY, Jan. 1947, pp. 6–9) of the experiments in which fertilisers such as sodium nitrate, ammonium sulphate and superphosphate were spread on the waters of Loch Sween and gave rise to bigger 'crops' of plankton, bottom-feeders like shellfish and sea-worms, and fish. The growth rate of young plaice, for example, was increased five times. The Norwegians have tried the same method to produce bigger yields from the oyster farms which they run in their fjords.

Prof. J. E. G. Raymont, of the University of Southampton, who was associated with the Loch Sween experiments, enlarged upon this subject. He suggested that these and other experiments gave results sufficiently encouraging to justify pilot-scale schemes to test whether an artificially increased plankton crop could be harvested and utilised direct.

But once again the listener could not help wondering when experiments will be carried out to test whether man can in fact stomach a diet of plankton. This point needs to be investigated at an early stage, and it must not be allowed to be forgotten in the rush and tumble of getting a new material into quantity production (as happened unfortunately in the case of food yeast). It is not enough to launch a new foodstuff on the market if one's claim for high nutritive value is based solely on the protein-fat-carbohydrate figures given by chemical analysis. There is a tendency to discuss these new ideas as though the main problems to be solved are those involved in getting the new food into industrial production; whereas these problems should be tackled *after* and not before the nutrition experts have tested the new food and assessed its real feeding value.

The conference included one very useful paper by Mr. M. L. Parry, a Colonial Office fishery officer working in Malaya, about the practical problems that have to be solved before such things as motor boats can be introduced to the advantage of the native fishermen. He stressed the risks of making technical changes in the wrong way: for instance, it is no use persuading the natives to acquire motor boats if this results in them mortgaging themselves up to the hilt so that the moneylenders and not the fishermen get all the benefit of increased catches.

Another extremely practical paper was that of Dr. C. F. Hickling, the Fisheries expert of the Colonial Office, who talked about marine fishponds. He mentioned the ponds in the Bay of Arcachon, south of Bordeaux, which Prof. Yonge described recently in DISCOVERY (June 1953, p. 183). These ponds 'support flourishing oyster beds, while fish such as mullets thrive in them. In this region there are some 600 acres of these marine fishponds and their annual yield of fish works out at about 300 kilograms per hectare. (A hectare is 2½ acres.) No artificial fertilisers whatever are used. Dr. Hickling also spoke of the brackish prawn ponds of Singapore, with an area of about 900 acres and an annual yield of 70–900 lb. per acre.

The greatest marine fishponds of all are the tambak systems of Indonesia and the marine ponds of the Philippines. The former, 200,000 acres in extent, produce each year some 33 million lb. of fish and prawns—about 15,000 tons, which is equivalent to 170 lb. per acre. Where the ponds are on juvenile volcanic soil the yield is as high as 380 lb. (A full account can be found in W. H. Schuster's *Fish Culture in the brackish water ponds of Java*, an F.A.O. publication.) Dr. Hickling pointed out that these ponds give a yield of animal protein as great or greater than that of fertilised and cultivated pasture land, and that the yield has not diminished for scores or even hundreds of years.

The conference was undoubtedly a great success, and it is intended to publish its proceedings in book form if the demand justifies it. Interested readers should contact the Institute of Biology direct, at Tavistock House South, Tavistock Square, London, W.C.1.

# AUTOMOBILE DEVELOPMENT

W. HAROLD JOHNSON

People who enjoy an argument sometimes like to exercise their whim on the thesis that the motor car has made no major material advances during the past forty years. The underlying idea is that the modern car is *essentially* the same in principle as it was when it first became a practical vehicle. Anything more ridiculous is hard to conceive.

It is of course true that like its ancestor the modern car has a radiator (or other cooling device) and an exhaust system that dissipate heat for which we pay good money and would much like to use. It is true that an engine still consists of pistons going up and down in cylinders and so consuming mechanical energy that we would also like to use and that transmission of power from engine to road wheels is generally through a clutch and gear-box very similar to those of which an inventor (Panhard) could think of nothing better to say than 'ça marche'.

I have actually heard one of these detractors say that car designers have made no efforts at real progress and getting out of a narrow rut. Let us look at these charges.

We still have radiators that waste heat and they still contain water. So recently as a decade ago, checking the water level was a very necessary maintenance job at least once a week, and a few years before that the life of a radiator was largely speculative. Today we fill our radiators if and when we think of it: pressure cooling systems are the rule and a very good rule too. The life of a radiator is almost that of the complete car and the once common leak has become a rarity.

We still have pistons in our engines, but what a difference here. The old cast iron pots of 4 in. diameter, of which four had to go up and down for about 5 in. to give an alleged horse-power of twenty-five are now replaced by aluminium cups about 2½ in. diameter and travelling only 3½ in. to give an actual forty horse-power or more. This is the output of many one and a quarter litre modern engines, but when the designer gets down to producing real power he can and does get 100 b.h.p. per litre from a high efficiency modern internal combustion engine. Admittedly this is uncommon, but it is definitely possible. If that is not progress, what does the word mean?

Put the man who has learnt to drive on a modern small car or motor bus on to their respective ancestors of only 25 years ago and see what he can do with those old clutches and gear-boxes, allegedly the same as those of today. You needn't wait for his comments, the poor old gear-box will make them audibly known long before he and his vehicle come into sight, if ever they do. I remember many years ago trying the hydraulically controlled clutch pedal (not clutch) just introduced for the L.G.O.C. buses; most modern bus drivers would go on strike immediately if even asked to put up with such a 'refinement'. To them a hydraulic clutch with a pre-selector gear-box is a first essential for their consent to drive.

As for lack of enterprise on the part of the designers the critics may perhaps be pardoned for ignoring that the first idea of jet propulsion for any kind of vehicle was Sir Isaac Newton's 'automobile', which admittedly never existed except on paper. But the internal combustion turbine, and also jet and rocket propulsion were tried on cars and motor cycles long before they were applied in the air. It was an electric car that first attained a speed of 60 m.p.h., a steam car that first did 75 m.p.h. and another steamer that first managed over two miles a minute.

The fact that all these propulsion systems have been unable to compete with the simple internal combustion engine is perhaps the most potent argument in favour of the universal power unit of today, and of the acumen and skill of its designers in sticking to it. Publicity is occasionally given to what we are told will be a completely revolutionary design of prime mover for road vehicles, but the results so far have always been the same—it is quietly dropped and the designers go back to their pistons and petrol. Not because they don't know or won't think of anything else, but because petrol and pistons do the job better.

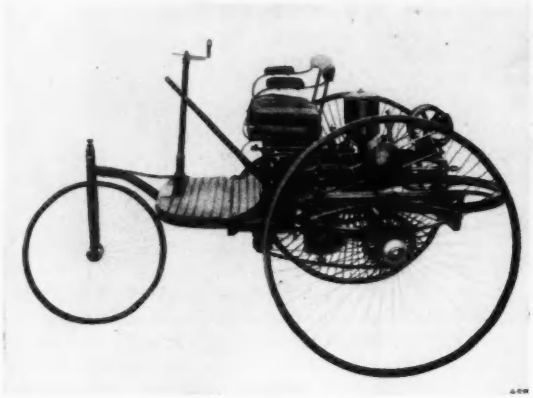
Some of us may have regrets that the steam car disappeared. More than twenty years ago I was closely associated with a movement to revive it: the movement failed not because there were no designers, but because there was no one else who could appreciate the steam car and its possibilities. The public just would not have it. The man in the street was too well satisfied with his petrol and pistons —and how often is the man in the street wrong?

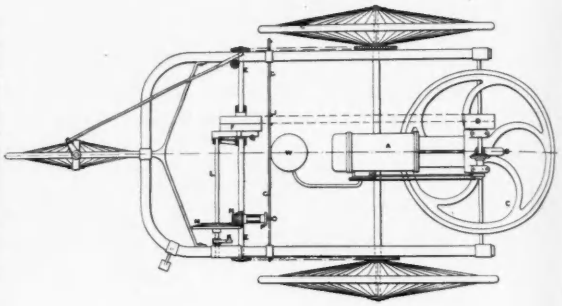
## TRANSMISSION

Apart from prime movers, car designers have not been slow in transmission systems. It must be nearly thirty years ago when we were offered the Entz electric system on the Crown Magnetic car (known in America as the Owen Magnetic) with an engine of about 40 h.p. and reintroduced over here with a h.p. of 15·9. It was one of the most amusing things to drive ever on the road, but unfortunately its weight reduced its overall efficiency to such an extent that it was hardly practical. My recollection of it is that the 40 h.p. model had a maximum speed of 45 or 50 m.p.h. which even in those days was not good enough. But to be able to start an engine and stand away from the car when it gradually began to move so that one could stop it with a hand on the radiator and move away to let the car gradually climb up the kerb if necessary, used to thrill everyone who saw it.

The Tilling-Stevens and Daimler electric transmission systems, which were quite different, were successful for many years on buses and other heavy vehicles but once again had to yield to the higher efficiency of the positive system, which is now universal.

Much the same applied to a device like the Constantinesco torque converter though here the trouble was not weight but—well, it just did not catch on. Perhaps the inventor was partly responsible because he would not produce or license his torque converter for an existing or conventional car, but insisted on offering it with his





FIGS. 1–4. THE FIRST BENZ CAR, 1885. In Fig. 2 the single belt is seen to convey the drive from the engine pulley D to the loose and fixed pulleys F on the counter-shaft.

vertical twin two-stroke engine. I well remember how when he demonstrated the wonderful capabilities of this system to me round Victoria Station my interest in the performance was almost swamped by wonder as to when I should actually be thrown out of the car by the vibration of the engine!

Whether electrical transmissions will ever come back is doubtful in spite of the improvements that have been made in them over the years, especially in the reduction of weight, but a torque converter of some sort is of course promised for the future and is available on some American cars, and a further American application is available on at least one English car produced for the export market.

Much the same applies to the car as a whole—i.e. as distinct from its power unit or transmission system. In 1914 the Wolseley Company built for Count Schizovsky his gyro-car—a two-wheeler that rightly aroused much interest. This did not show lack of enterprise, but the next four years did show that four wheels would take a lot of beating, which they have not yet had, but that is not for lack of experimental designs.

After all this, it is difficult, I think, to maintain the thesis that car designers are or have been slow and unenterprising. Let us look in rather more detail at some of the things they have done by surveying the modern chassis and summarising its dominant features.

## METAL AND OIL

A necessary preliminary is to emphasise some of the developments not limited to the automobile sphere on which automobile engineering fundamentally depends. Of these perhaps the most important is in the metallurgical field. If metallurgy had not advanced as it has in the last half-century, modern motor cars, and indeed any other internal combustion engine of the present day, could not exist. One of the handicaps under which early designers suffered was not so much lack of knowledge or theory, but lack of the necessary materials for putting their knowledge and theories into practice. I would not go so far as to say that given the aluminium and steel alloys of today Panhard and de Dion could have produced the modern engine, but they would certainly have produced much more efficient engines than those with which they had to be content.

The same applies throughout the whole chassis. We take the modern gear-box for granted, but deprive it of its high quality steels and it would be very different—more like the huge boxes fitted to old cars and still seen in some marine applications.

Next to the metallurgist come the pure chemist and the petroleum technologist. It is true that towards the end of the first decade of this century the petrol we obtained for about one shilling per gallon was better than much that we get today, or used to get until recently, but it is also true that today we are offered better fuel than ever before, even if we have to pay through the nose for it. High octane fuels are essential for modern high efficiency engines. Good lubricating oils are not less essential to modern high performances. It is not so many years ago that oil put into an engine soon developed an acid content that did far more harm than the oil did good, and the diversion to vegetable oils was a temporary expedient that produced almost as many disadvantages as advantages. Now the petroleum technologist produces petrol that makes possible higher compression ratios than ever before, and higher engine speeds than the pioneer designer could imagine in his wildest dreams. But take away modern lubricating oil and you may as well go back to the engine design of at least thirty years ago.

After paying this necessary tribute to the chemist in metal and to the chemist in oil, to the metallurgist and to the petroleum technologist, we may turn to the details of the modern automobile chassis.

## THE POWER UNIT

The radiator comes first and reference has already been made to its two features of most concern to the car owner—its comparative freedom from serious leaks and the absence of need for frequent topping up. Constructionally nearly all modern radiators are of the honeycomb type, the simpler gilled tube having almost disappeared: functionally they work under thermostat control (which only fails occasionally) with a large header tank and often under some pressure as in aero-engine practice. Anything that

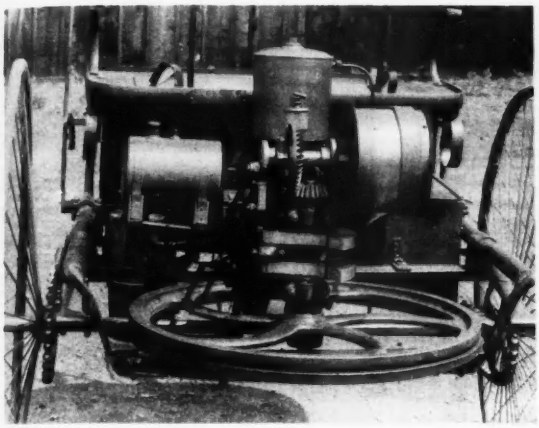


FIG. 3. Rear view of the 1885 Benz.

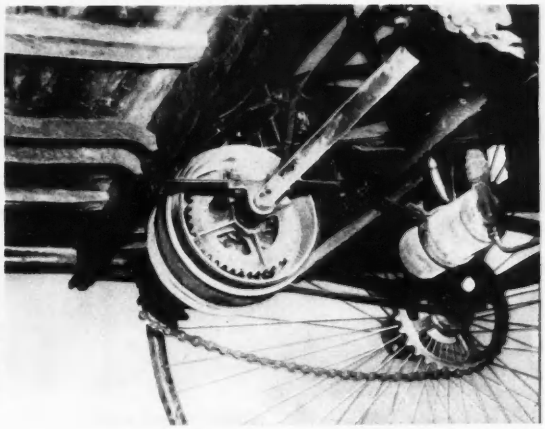


FIG. 4. Differential gear and back axle.

will accelerate the attainment of a useful working temperature and that will keep this temperature high without excessive water consumption is good for the engine and good for the car owner.

Next to the radiator comes the engine, the item of major interest to most users. Many observers seem to regard the 'new' ideas about bore/stroke ratios as the most interesting recent engine development. I can hardly agree. In the first place there is nothing new in this idea of a square or over-square engine—an engine in which the bore equals or exceeds the stroke. Forty years and more ago 85 × 85 mm. were the bore and stroke of a popular motor-cycle engine and many car engines had similar ratios even though there were some striking exceptions, such as the 80 × 180 mm. of the 15·9 h.p. Hispano-Suiza, that gallant predecessor of the 'family sports' cars that have included the Bentley, Lagonda and the Jaguar. But in spite of the over-square Fords and other cars with an American ancestry, it is significant that the big Canadian Ford has an almost square engine (90 mm. bore and 91·4 mm. stroke) and that most European and especially English cars favour a stroke of something between 20% and 40% in excess of the bore. In spite of the theoretical advantages of the short stroke engine—lower piston speeds for a given r.p.m. with consequent reduction of cylinder wear and so forth—it does not appear to be sweeping all before it.

Designers cannot overlook that its advantages are largely theoretical, that it is little use to reduce your piston speed per r.p.m. if you have to increase your r.p.m. to maintain your power output. And, so far as I know, no one has yet discovered how to get horses out of an engine except in terms of volume swept in unit time. Engine speeds have been going up now for years, irrespective of bore/stroke ratios, and veteran motorists cannot hear without a gasp of 5000 r.p.m. as a normal maximum for a modern standard 3½ litre engine, knowing as we do that the design shops are frankly thinking about double such speeds for special jobs—and in some cases getting them.

Next to these high speeds, I would put valve design as the most significant engine development, and this is of course, a determining factor in engine speed. Direct operation of valves with multiple springs from one or two overhead camshafts has sent up engine speeds and outputs more than any other single factor. But all the overhead valves in the world could not do their stuff without properly designed cylinder heads (hemispherical or nearly hemispherical combustion spaces) and modern light-weight pistons. The metallurgist is entitled to much of the credit for both the new valves and the pistons. It would be useless for the designer to come along with his high-lift cams working 2500 times a minute if the valve would not stand up to the heat and the shocks.

It may be a somewhat unconventional opinion, but I should not be very surprised if the next few years saw an attempt to restore the single sleeve valve to car engines. One of our great theorists and designers, no less an expert than Sir Harry Ricardo himself, is a strong advocate of this type of valve, and he points out with justice that the old Argyll car did not fail through any fault in its Burt McCullum valves. Since those days these valves have been highly developed for aero-engines and it is ironical that this development came only when the aero piston engine was nearing the end of its days. Similarly if the marine application of the single sleeve valve had come after this aero development instead of many years before its history might be very different. The single sleeve, with its combined reciprocating and oscillating motion, has advantages that the popping poppet cannot hope to achieve.

No one can look at a modern car engine without being struck by its apparent complication, by the excrescences and auxiliaries that seem to cling all over it. Many of them seem justifiable, but many are due to the modern craze for automacity. Everything must work itself, the car driver must not be expected to use skill, or even intelligence. Whose fault is it if the average modern driver justifies this opinion of his capabilities or lack of them? The designer thinks that we could not be bothered to work a simple ignition timing lever and so he gives us automatic timing and he may be right, but many of us are far from convinced that this among so many other automatic gadgets really does the job so well as we could do it.

Similarly with the automatic carburettor, which is much

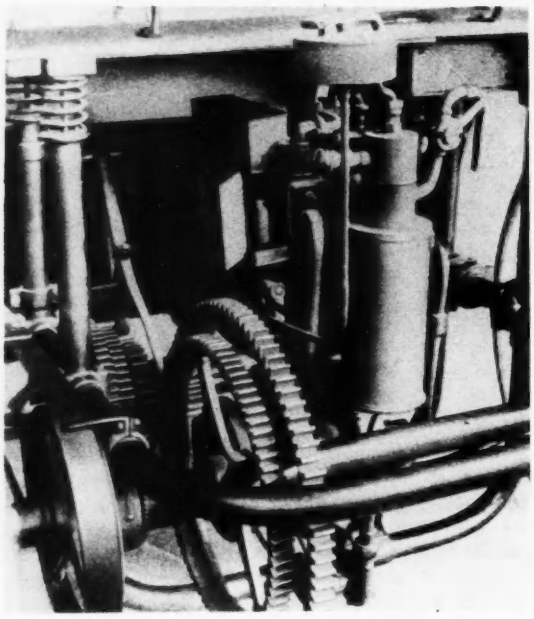


FIG. 5. The sliding change-speed gear of Gottlieb Daimler's second car of 1889.

older in general application than automatic ignition timing. We drivers have almost forgotten about extra air valves and mixture controls that we had to work by hand if we wanted fair results and economy in fuel, but while admitting that the modern carburettor is efficient I do wonder whether the automatic thermostatically controlled choke is always as good as it seems, with its instantaneous starting of the engine.

I often wonder also whether drivers would not prefer to have some individual controls that might enable them to utilise modern progress towards getting more miles per gallon rather than easier control. One respect in which the modern engine is definitely not superior to its predecessor of thirty years or so ago is in its fuel consumption. Yes, it may give a higher power output, higher speeds and better hill climbing, but it does not give us the more miles per gallon that some of us would prefer for our four-and-sixpences. We cannot have it all ways, of course.

One adjunct to the carburation system that must be universally welcomed is the air cleaner. But for this, decarbonising would have to be a much more frequent maintenance operation than it is, and a reduction in maintenance outlay is good for everybody except the garage proprietor. Much the same applies to the external oil cleaner. We have always had internal oil filters and we still need them: we should need them much more and our reboring bills would be even bigger than they are but for these external and changeable cleaners.

Of engine design in general I cannot say much more than indicate the complete victory of the four-cylinder monobloc for all but the largest units where the six (also monobloc) seems established as the maximum acceptable cylinder number. Indications of a few years ago that luxury cars would favour eight or twelve cylinders in their engines have been falsified. To some extent this is due to better engine construction and balancing, but perhaps even more to flexible mounting. What little undamped vibration the modern engine may generate is successfully absorbed by its flexible mounting in the chassis.

As for engine types, something should perhaps be said about the so-called diesel—that was a useful debunking article in DISCOVERY (Aug. 1953, 236–7), for it is surprising how few people knew that the diesel engine is an English invention—and about the turbine. Personally I attach little importance to either, in the sense of expecting them to become common power units for our cars within say the next decade. They may have some advantages over the ordinary internal combustion engine, but in car applications I can think of no asset of either diesel or turbine that is not outweighed by corresponding disadvantages. For an unconventional power unit to be generally adopted for any purpose it must not only be capable of satisfying that purpose, it must satisfy demands better than existing engines do. And within the limits of practicality, what can either diesel or turbine do that the piston engine cannot do just as well or even better?

The piston engine has the diesel beaten on first cost, on maintenance cost (in spite of all that diesel protagonists may say to the contrary!) in smoothness and flexibility of running, and in overall weight. The turbine may score in smoothness and in weight, and both diesel and turbine should also score in fuel cost. But these advantages are not likely to outweigh the simplicity, the cheapness and the handiness of the petrol-drinking piston engine, which anyone can understand and which most people can handle. All this of course, is in application to ordinary private cars: when it comes to big vehicles—lorries and buses—then both diesel and turbine may ultimately capture the field as indeed the diesel has already.

## TRANSMISSION SYSTEMS

For ordinary drivers the significance of the transmission system is largely one of controlling his car. The change from the crash or sliding pinion gear-box to the synchro-mesh has simplified gear changing beyond all measure, and the fluid fly-wheel with epicyclic gear-box has carried this desirable process much further. Whether it needs to be carried still further may still be a matter of opinion. The Americans certainly seem to think that it does, hence their

"THE SPIRIT OF THE TIME SHALL TEACH ME SPEED"
Shakespeare
King John, Act IV Scene 2
PETROL LUBRICATING OILS & GREASES
CARLESS, CAPEL & LEONARD,
HACKNEY WICK, LONDON, N.E.

FIG. 6. In Britain the first cars ran on spirit produced by Carless, Capel and Leonard. It was W. J. Leonard who coined the word 'petrol' for motor spirit.

FIG. 7. The Chevrolet sports car has a body of resin-bonded glass fibre, which is far lighter than its ordinary metal counterpart. To start with, Chevrolet intend to make 5000 of these cars.

so-called hydromatic and other fancy ratio-changing systems that relieve the driver of any need to use skill: one pedal for the brake, another for the accelerator and nothing else to bother about in the mechanical control of the car. Most drivers of my acquaintance like to have something to do and something in which they can exercise, or think they can exercise, their skill and I am definitely with them.

In spite of this and because what the Americans demand today the world will have tomorrow these automatic transmission changing ratios or torque converters, call them what you will, are likely to be universal on all but the smallest and cheapest cars within the next ten years. But before that achievement materialises all over the world, shall we see any manufacturer with enough courage to discard the steering column control for the existing gearbox? I have yet to meet a driver with more than a few years' experience who has a good word to say for this new-fangled abortion forced on an unwilling public by manufacturers who do not like it, but who must sacrifice all preferences however reasonable for an export market dominated by this American craze for something new. A centrally controlled gear box with a free-wheel and an overdrive in the transmission line would more than satisfy all owners who know how to handle a car and may well become standard practice before the torque converter and two-pedal control become fully established.*

Back axles are now universally fitted with the hypoid bevel drive so that there is little to comment on here, but as for the chassis as a whole, perhaps a word should be given to the general lightening that has accompanied a general strengthening with the box girder construction and with the unit construction of chassis and body. This is sometimes hailed as a novelty introduced after World War II, but actually it was employed on the English Lagonda cars well before the First World War, and on the Italian Lancias very soon after. Some estimate of the esteem in which it was then held may be formed from the fact that many insurance companies refused to insure such cars except at an increased rate. Today it is widely used and commonly accepted, but would it be indiscreet to ask if recent increases in car insurance premiums are in any way connected with the practice? Damage to two units built as one is obviously likely to be more difficult and more costly to repair than damage to either unit that can be tackled separately.

This invites a few comments on the general question of accessibility, a matter in which cars steadily get worse and worse. More and more is even the most mechanically minded owner-driver forced to take his car to the makers' agents for quite ordinary maintenance and repairs. Some people may like these modern beetle-like cars with their chromium-plated grins—until it is necessary to get at the engine.

## PLASTICS IN CAR CONSTRUCTION

Perhaps this is more a matter of body design than of chassis construction though when chassis and body are one there is not much to choose. But if ever we get plastic bodies, not to say plastic chassis, where shall we be then when it comes to repairs? You can get through a sheet of

* Since this paragraph was written the Rover Company of Coventry have announced and shown at Earl's Court their reversion to the central gear lever. Obviously this Company is determined to maintain their half-century reputation as a pioneer of good design and practice.

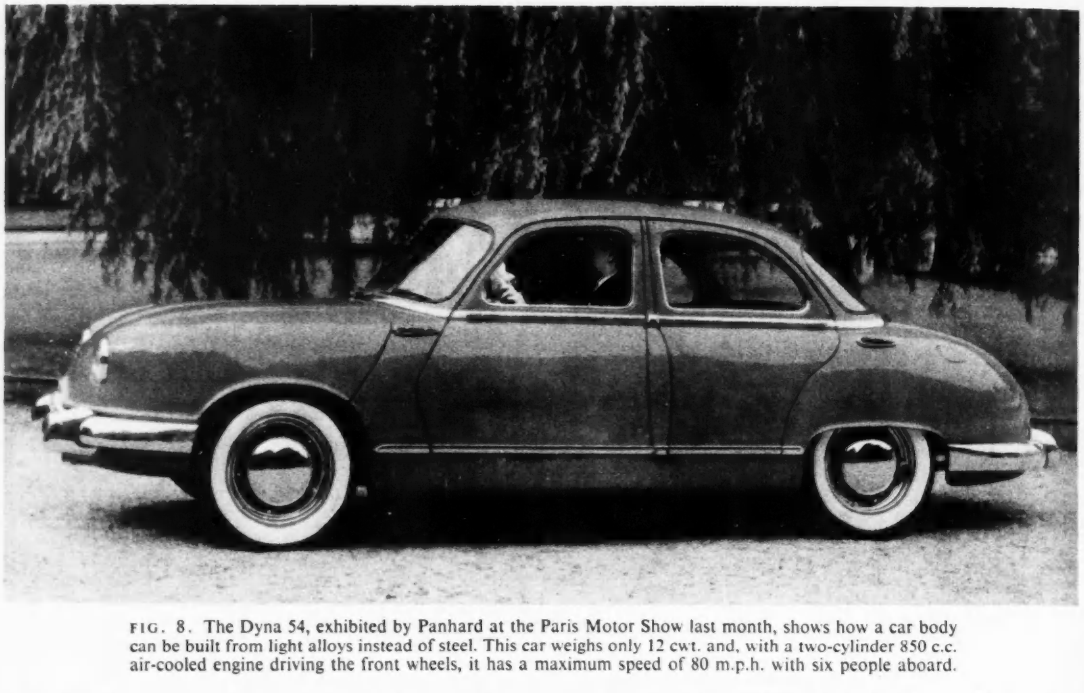


FIG. 8. The Dyna 54, exhibited by Panhard at the Paris Motor Show last month, shows how a car body can be built from light alloys instead of steel. This car weighs only 12 cwt. and, with a two-cylinder 850 c.c. air-cooled engine driving the front wheels, it has a maximum speed of 80 m.p.h. with six people aboard.

tin with a tin-opener and you can repair the gap with a welding flame, but you cannot do either with plastic, at least not with a thermo-setting plastic, which so far as I know is the only kind so far suggested for use in car construction. Now that nearly all bodies and many chassis are pressed out of sheet steel in huge power presses it may seem logical to ask why not use the same process but with plastics instead of steel as the raw material. But instead of asking why not, I would like to ask why?

Whether there would be any saving in cost or in weight is arguable. There might be in certain cases but in others both weight and cost would be higher than for similar designs in metal—I am, of course, assuming a continuance of present production costs for both steel and plastics. When the plastics advocate urges that his material would be stronger than steel surely he is indulging in a little mild leg-pulling. Plastics certainly have their uses in car construction, chiefly in the way of components such as facia boards and the like which are ornamental rather than structural. Some uses exist for the laminated plastics, mainly in small components, though applications here are not extensive apart from electrical units. I feel sure that in spite of the daily newspaper headlines about motor-car bodies made from soya beans we have a long way to go yet before the so-called plastic car becomes a commerical reality.

There are two rather important details of the car so far not mentioned—suspension and steering, which together affect the way the car holds the road. This last is a matter in which cars have improved vastly during the past decade, as indeed was essential with increasing speeds. And tied up with suspension and steering is braking, without which no car is safe and which is indeed one of the prime factors in determining the safety limit.

Independent springing started rather discouragingly on ordinary cars about fifteen years ago and is still inclined to involve increased wear on the tyres. However, it has undoubtedly come to stay if only because fashion demands it, and in some cases it does give better riding than the older, simpler and cheaper 'semi-elliptic springs'.

Hydraulic brakes are no longer inclined to fail through the bursting of a pipe-line and it is well that the servo-assistance which was popular some twenty years ago is not generally regarded as necessary nowadays, except in the actual shoe operation inside the drum (which is hardly the same thing even if the effect is similar). An interesting braking development that will be watched eagerly is the disk brake, where a steel disk is gripped as in a vice by a rubber—or plastic—lined shoe generally open to the weather and to the road mud. But it may not suffer from the faults of the similarly exposed external contracting band brake which has now gone for ever. It is possible to put up a good case for the thesis that the credit for the improved car performances that we take for granted is due as much to improvement in braking as to anything else. That may be a rather extreme view but certainly it would be worse than useless—it would be dangerous—to give road users vastly better engines without correspondingly better braking, steering and suspension—in other words better road holding and controllability. All that the motorist wants now to give happier and safer travelling for all road users is better roads.

# CHARLES STANHOPE (1753-1816)

Although scientific progress owed much to aristocratic patronage in the 18th century it is rare to find a hereditary peer who was also a practical scientist of genius. Indeed the versatile and forceful Charles, 3rd Earl of Stanhope, is distinguished from his fellow peers not only by his remarkable inventions in printing, steam navigation and shipbuilding, calculating machines and in other applied arts, but also by his opposition to practically everything the aristocracy stood for at that time. He was born 200 years ago on August 3, 1753, but in his attitude to many scientific and social matters (he was an ardent supporter of the French Revolution) he was much in advance of his time.

Gutenberg's wooden printing press remained essentially unchanged for 300 years before its first major revolution was introduced about 1800 by the invention of the 'Stanhope levers'; this system enabled a much greater pressure to be exerted and, as in all modern presses, the pressure was rapidly increased at the exact moment of printing. To allow the frame of the press to stand up to the greater stresses Stanhope substituted iron for wood in the construction of the frame and thus pointed the way for the whole art of printing to advance rapidly from medieval to modern methods. Stanhope made his inventions, including his process of stereotyping, freely available to others and his dream of spreading knowledge more widely and cheaply through the medium of printed books was realised in his own lifetime. The Stanhope printing presses gave remarkably long service, and it is quite possible that one or two are still functioning. According to a letter published in *Museums Journal* recently (July 1953), a Stanhope press made by Edwards and marked No. 26 has only just been taken out of service by the directors of the *Western Mercury and Somersetshire Herald*, who were offering it to any museum that would pay the cost of carriage.

Stanhope's experiments with steamboats began just before Watt introduced his rotative steam-engine, so it was natural he should use the obsolescent 'duck's foot' mechanism in which an arm swinging below the vessel was driven to and fro by a horizontal steam-engine (which he also designed). By means of metal vanes hinged at the bottom of the arm greater pressure was exerted on the water during the back stroke than during the forward. The motion was certainly rather jerky, but the unprogressive Navy Board of the Admiralty, after a single and promising trial under unfavourable conditions, condemned it and the whole principle of steam navigation.

It was many years, too, before Stanhope's attempts to place ship construction on a sounder scientific and hence economic basis became generally accepted; naval vessels at this time had an average life of only ten years. The new principles were summarised in the patent he took out in 1807 for the 'Stanhope Weatherer', a model of which he experimented with on the Round Pond in Kensington Gardens. Besides purely structural innovations he proposed for this vessel an extraordinary system of adjustable gills, flat metal plates about 2 feet square, arranged in a horizontal row below the water-line. These gills were hinged and could be opened out horizontally from the ship's side by levers. The four sets of gills at the four quarters of the ship could be controlled independently in such a way that the ship rode more steadily through heavy seas. The greater resistance to rolling offered by this device anticipates later attempts at ship stabilisation which culminated in the type of fin stabiliser fitted to the P. & O. liner *Chusan*. Other ships fitted with the same type of stabiliser include the *Andes* (the flagship of the Royal Mail S. American Fleet) and the British Transport Commission's cross-channel steamer *Falaise*. All the *Hunt* class destroyers of the British Navy are similarly equipped.

Stanhope's proposals for protecting ships against mines also seem remarkably modern as does his invention of a mine-sweeping device similar to the present paravane.

Two of Stanhope's calculating machines, built in 1775 and 1777, can be seen in the South Kensington Science Museum. In these, multiplication or division is carried out by the method of successive addition or subtraction; they were much ahead of their time in mechanical design and can deal with numbers up to 12 digits. The later machine, operated by rotating a handle, is not unlike a modern desk calculator. Stanhope realised that complex logical problems could also be treated by mechanical means and was the first to construct a simple logical machine to carry out such operations.

Stanhope contributed to many other fields of science. Thus he made many original experiments in electricity, and is credited with giving the first correct explanation of the 'return stroke' in lightning discharges (see his *Principles of Electricity*, 1779; also the *Philosophical Transactions*, 1787), and showing how fatal effects were sometimes produced at some distance from the place actually struck by lightning. He played a major part in getting the pointed lightning conductor accepted in the face of powerful opposition from supporters of the rounded conductor.

He was a pioneer in canal construction, and here he greatly influenced the American, Robert Fulton, who also learnt much from Stanhope's work on steam navigation. He devised for his canals a system of inclined planes instead of locks, and later proposed lifts for the same purpose. He gave a famous practical demonstration of how to prevent the spread of fire in buildings by eliminating the circulation of air, and suggested modifications to the new equi-tempered scale in music so that the individual characters of the keys should not be lost. His new type of lime-kiln represented a considerable advance and he invented various 'compositions' for roofing purposes and for the hulls of ships.

There is no doubt that Stanhope was a scientist and inventor of genius; he was also an enlightened, if not always practical, economic and social reformer. When all sides of his versatile character are considered he stands out clearly as one of the most powerful intellects of his age.

F. M. BEATTY.

*Every Wollaston Medal presented by the Geological Society is struck in palladium.*

# PALLADIUM AND ITS ANONYMOUS DISCOVERER

A. K. PARKER
M.A.

'PALLADIUM; OR, NEW SILVER, HAS these Properties amongst others that shew it to be a NEW NOBLE METAL . . . IT IS SOLD ONLY BY MR. FORSTER, at No. 26, GERRARD STREET, SOHO, LONDON. In Samples of Five Shillings, Half a Guinea, & One Guinea each.'

Such was the text of a handbill circulated anonymously in London in 1803. Who was the advertiser who launched a new noble metal on the world in this extraordinary manner? Was he a charlatan or an alchemist? Far from it, for the discoverer of palladium was one of the most respected scientists of his age.

But you may well ask: Why was the announcement made in this surreptitious way?

The scientist who discovered palladium 150 years ago was Dr. W. H. Wollaston. He had been experimenting in his laboratory at 14 Buckingham Street, Fitzroy Square, hoping to discover a method of rendering platinum malleable so that it could be made into evaporating vessels to contain sulphuric acid and other corrosive liquids. However, his experiments did not go the way he expected but they did lead him to discover the presence of a new substance to which he subsequently "gave the name palladium, from the planet that had been discovered nearly at the same time by Dr. Olbers."

But the presence of this new element—for such it proved to be—did not explain completely his lack of success. Wollaston wanted however to establish a prior claim to the discovery so he adopted the unusual course of announcing the new metal anonymously and selling samples of it through the natural history shop kept by Mr. and Mrs. Forster in Soho. He was thus able to keep secret the details of his unfinished work on platinum.

As was to be expected, the manner of his announcement raised suspicion in some quarters that palladium was not really a new metal at all. An amiable young dilettante named Richard Chenevix visited Mrs. Forster's premises and bought her entire stock. Only a fortnight later, he claimed that it was really an alloy of platinum and mercury. Wollaston replied anonymously, through the medium of *Nicholson's Journal*, by offering a reward of £20 to anyone able to make 20 grains of palladium. The "three gentlemen chymists" who were to act as umpires were Nicholson, Charles Hatchett, and Edward Howard. The reward went unclaimed.

Meanwhile Wollaston continued his experiments and discovered yet another new metal in the native platinum ore—this element he called *rhodium*, from the Greek word for a rose, as its salts are a rose-pink colour. Later, Wollaston perfected a method of producing malleable platinum and he was then able to come out into the open about the whole affair and claim due credit for his discoveries. Chenevix remained unconvinced for a time, but was reconciled to Wollaston some years later.

What kind of man was Wollaston? It is obvious that he was an unconventional character, and that his actions were occasionally a little eccentric. Certainly he was extremely resentful of curiosity in his affairs and went to unusual lengths to guard the privacy of his laboratory. The story is told of how a gentleman of his acquaintance found his way into Wollaston's laboratory while waiting for him to appear. On discovering the intrusion, Wollaston solemnly led the man to the "most sacred spot in the room", saying "Mr. P., do you see that furnace?" "I do," replied Mr. P. "Then make a profound bow to it, for as this is the first time, it will also be the last time, of your seeing it."

On another occasion a foreign philosopher called upon him with letters of introduction and asked to see his laboratory. Wollaston immediately produced a small tray containing some glass tubes, a blow-pipe, two or three watch-glasses, a slip of platinum and a few test tubes. He appeared to take a delight in showing by what small means he could produce great results. Much of his work was conducted on a miniature scale that called for the exercise of very delicate manipulative skill; doubtless he was helped in this by his extremely acute senses. One historian has described his ability to write with a diamond upon glass in characters so small that only a ragged line was visible to the naked eye; yet, when the letters were viewed through a microscope they were seen to be beautifully regular and quite legible.

Another story recorded by G. Wilson* also illustrates Wollaston's delight in minutiae. It relates to his early electrical experiments. After witnessing the brilliant combustion effects produced by means of the grand galvanic battery of Mr. Children, Wollaston met a fellow chemist in the street and stopped him. According to the anecdote as told by Wilson, Wollaston led him into a secluded corner and then produced from his waistcoat

* Essay on Wollaston in *Religio Chemici* (Macmillan, 1862).

pocket a tailor's thimble containing a galvanic arrangement. After pouring into this tiny battery the contents of a small vial, he proceeded to heat a platinum wire to white heat with the current generated by this contrivance.

Nothing remains of the laboratory in Buckingham Street, now Greenwell Street, as all houses on the north side of the street were destroyed during the Blitz. With the house disappeared the plaque which commemorated Wollaston's association with the building, and which was unveiled in 1934 by Sir Frederick Gowland Hopkins, Wollaston's far distant successor as President of the Royal Society.

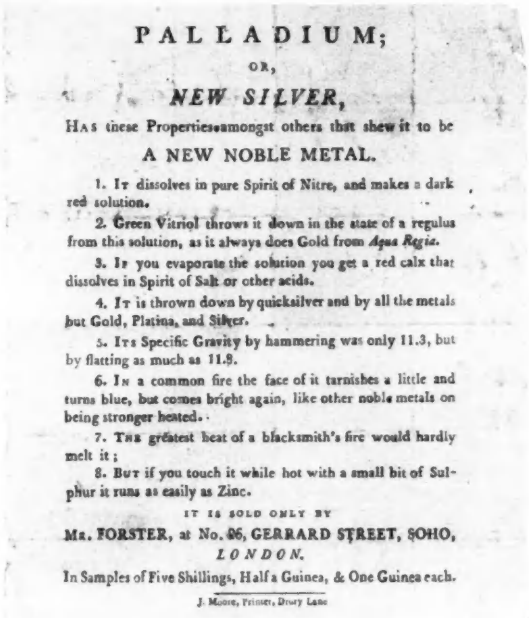
Like his great contemporary, Lord Nelson, William Wollaston was the son of a Norfolk clergyman. He was brought up in an atmosphere of learning, his father, grandfather and three uncles all having achieved some eminence in the world of science.

William set out to be a doctor and, after taking his medical degree at Cambridge, he began to practise in Huntingdon; afterwards he put up his plate in Bury St. Edmunds. Eight years later he gave up medicine—for an unusual reason: he was over-anxious for his patients, whose sufferings caused him acute mental distress—in his own words, "Allow me to decline the mental flagellation called anxiety, compared with which the loss of thousands of pounds is as a fleabite."

From that time onwards he depended on applied science for his livelihood. His discovery of the method for rendering platinum malleable brought him a considerable income, so perhaps his secrecy about his methods was quite justified. Some accused him of too great a love of money, but on occasions he could be extremely generous as the following story bears witness. His brother Henry, being involved in unexpected difficulties, applied to William to use his influence in obtaining for him a Government situation. Wollaston, always a conscientious man, replied "I have lived to sixty without asking a single favour from men in office, and it is not after that I shall be induced to do so, even were it to serve a brother. If the enclosed can be of use to you in your present difficulties, pray accept it, for it is much at your service." The 'enclosed' was a receipt for £10,000 worth of Consols.

Although he never married, Wollaston could not be called an unsociable person. He was a regular member of 'The Club', the illustrious dining club founded by Sir Joshua Reynolds and Dr. Johnson, and he also derived and gave great pleasure in the society of children and young people. He was fond of the theatre and of music. He played chess and billiards, and his outdoor sports included fishing and shooting. He travelled widely, both at home and on the continent of Europe, and his letters bear witness to the deep interest he displayed in everything and everyone he saw or met—the people and their customs, the buildings and factories, paintings, and the countryside itself.

Portraits represent Wollaston as a grave, silent and meditative man. But he was not always so, for it is recorded that "the inquisition of the Commissioners of Income in 1800 changed his usual calm into a fever of extreme



PALLADIUM;

OR,

NEW SILVER,

HAS these Properties amongst others that shew it to be

A NEW NOBLE METAL.

1. IT diſſolves in pure Spirit of Nitre, and makes a dark red ſolution.

2. Green Vitriol throws it down in the ſtate of a regulus from this ſolution, as it always does Gold from *Aqua Regia*.

3. IF you evaporate the ſolution you get a red calx that diſſolves in Spirit of Salt or other acids.

4. IT is thrown down by quickſilver and by all the metals but Gold, Platina, and Silver.

5. ITS Specific Gravity by hammering was only 11.3, but by flatting as much as 11.8.

6. IN a common fire the face of it tarniſhes a little and turns blue, but comes bright again, like other noble metals on being ſtronger heated.

7. THE greateſt heat of a blackſmith's fire would hardly melt it;

8. BUT if you touch it while hot with a ſmall bit of Sulphur it runs as eaſily as Zinc.

IT IS SOLD ONLY BY

MR. FORSTER, at No. 26, GERRARD STREET, SOHO, *LONDON.*

In Samples of Five Shillings, Half a Guinea, & One Guinea each.

J. Moore, Printer, Drury Lane

*SCIENTIFIC NEWS.*

*Reward of Twenty Pounds for the Artificial Production of Palladium.*

THE following is a copy of a paper received by me under cover, by the two-penny poſt. It is written in the ſame hand as a note which covered a ſmall piece of the palladium mentioned to have been received by me laſt Midſummer. (See Philoſ. Journal, June, 1803. Vol. v. p. 136.) Upon inquiry, I find, that Mrs. Forſter has received the ſum of 20 £. with inſtructions conformable to this paper. This original is cut indent-wiſe on the margin, and has part of a manuſcript flouriſh or paraph on each border, but no ſignature.

(COPY.)

*December* 16, 1803.

SIR,

AS I ſee it ſaid in one of your Journals, that the new metal I have called palladium, is not a new noble metal, as I have ſaid it is, but an impoſition and a compound of platina and quickſilver, I hope you will do me juſtice in your next, and tell your readers I promiſe a reward of 20 £. now in Mrs. Forſter's hands, to any one that will make only 20 grains of real palladium, before any three gentlemen chymiſt's you pleaſe to name, yourſelf one if you like.

It is infiſted that palladium cannot be formed by art; and a reward is offered for any proceſs to that effect.

That he may have plenty of his ingredients, let him uſe 20 times as much quickſilver, 20 times as much platina, and in ſhort of any thing elſe he pleaſes to uſe: neither he nor I can make a ſingle grain.

Pray be careful in trying what it is he makes, for the miſtake muſt happen by not trying it rightly.

My reaſon for not ſaying where it was found, was, that I might make ſome advantage of it, as I have a right to do.

If you think fit to publiſh this, I beg you to give the names of the umpires, as I have deſired Mrs. Forſter to keep the money till next Midſummer, and to deliver it only in caſe they can aſſure her that the real metal is made by a certificate ſigned by you, and by them, on this check.

I hope a little bit of whatever is made may be left with Mrs. Forſter.

*Letter*

*These reproductions show respectively the anonymous handbill of 1803 announcing the discovery of palladium; and the page of "Nicholson's Journal" which carried Wollaston's challenge.*

The palladium rose bowl, designed and executed by R. E. Stone and presented to Princess Margaret by the Institution of Metallurgists.

indignation." A very human weakness, with which most of us can sympathise!

But above all he was a man of science, with a very high regard for truth. His judgment, even upon subjects remote from his own immediate pursuits, was so reliable, that, in the later years of his life, he became a universal arbiter on matters of scientific controversy.

For many years he was Secretary of the Royal Society and, later, its Vice-President. For a short while he served as President, but stood aside at the next election to allow the ambitious Sir Humphry Davy to succeed to the Chair. He served also on the Council of the Geological Society, which has honoured him by naming its principal annual medal after him; this medal is made of palladium, as is most appropriate.

Wollaston's scientific work was notable for its great versatility. Apart from his metallurgical work, he made contributions to medical science, atomic theory, optics, astronomy, the study of crystals and minerals, electricity, mechanics and botany. One of his most interesting inventions was the *camera lucida*, which was used by Chantrey and other artists in making portrait and landscape sketches. Fox Talbot, the 'Father of Modern Photography', recorded that his method of producing photographs on paper suggested itself to him while he was sketching Lake Como with the *camera lucida*.

The nature of his death showed Wollaston to have been a man of great courage. In July 1828, the pupil of his left eye became insensitive, and he was told that this probably signified a tumour on the brain. Realising that his end was near, he calmly set about dictating (he was then unable to write) the details of all his unrecorded work lest his unpublished discoveries should perish with him. This stoic resolution he kept up until his death on December 22, 1828.

And what of the subsequent fate of palladium, 'the new noble metal' which Wollaston had discovered? Public interest was centred on it and the kindred rare metals last month when the Duke of Edinburgh opened the Exhibition of the Platinum Metals, which was organised by the Institution of Metallurgists to commemorate the discovery of palladium 150 years ago and to pay tribute to Wollaston's great work.

At first pure palladium metal found few uses. Wollaston himself developed only one application for it—this was an alloy with gold that was used to make tarnish-resistant graduated scales for scientific instruments. (One notable example was the mural circle erected at the Royal Observatory, Greenwich, in 1812.)

Today palladium is accepted by craftsmen the world over as a precious metal for fine jewellery. It is less costly than gold and platinum and its lightness is an advantage that can be exploited in the making of large pieces of jewellery.

But palladium is not all glamour; it has besides many industrial uses. The efficient operation of many telephones, for instance, depends on the use of tarnish-resistant palladium contacts in the dialling mechanism. Palladium plays an important part in the catalytic conversion of the valuable antibiotic streptomycin into the derivative called dihydro-streptomycin, which is the form in which the medical profession generally uses this drug.

Palladium is a common constituent of the alloys used for many dentures. Like gold and platinum, this metal can be beaten into very thin leaf and then used for decorating such things as tooled leather bookbindings.

## SISTER METALS OF PALLADIUM

Palladium's elder sister, platinum was used for personal adornment over two thousand years ago, and today it is unrivalled as a jewellery metal and as a setting for precious stones. But it has many other more important but lesser known uses in industry on account of its 'noble' properties, important among which are its high melting point and its great resistance to chemical attack.

There are other metals in the platinum group, some of which are probably quite unknown to the layman. Rhodium, which Wollaston also discovered, can be used as a plated coating on cigarette lighters and the reflectors of powerful searchlights, as well as in motor-car headlamps. Iridium is probably present in the tip of your fountain pen; it is also a constituent of 'everlasting' gramophone needles, and osmium alloyed with iridium forms one of the hardest and most wear-resisting alloys in use today. Ruthenium, the youngest member of this family, is at present used only in the form of alloys with palladium to produce an ideal jewellery metal. The six metals thus form a family which plays a vital part in modern industry.

# MALTHUS AND THE SCIENTISTS

ARTHUR MARSH
M.A.

Judging by the volume of literature on Malthus which has been published recently, this is a Malthusian age. No fewer than a score of books have been published since the war with an implicit or explicit Malthusian inference. The most recent is a work edited by Professor D. V. Glass entitled *Introduction to Malthus*. (Watts & Co., London, 205 pp., 10*s*. 6*d*.)

This spate of literature and its meaning for scientists merits some explanation. Malthus published his first Essay on Population in 1798. Its theme, which he elaborated in later editions, was a simple one. If population rises faster than food supply, starvation and a reduction of population to what food supply will permit will inevitably result. This is not a theory, it is a truism which the ecologist will be the first to appreciate. It gives no rise in itself to argument. Argument about Malthus has other roots. Ecological balance involving animal life is one thing; that involving man is another. Malthus himself was unwilling that his own "law of population" should be permitted to act in its own crude way. If the population of Britain was, as he feared, about to become too large for the means of subsistence, compassion and common sense both dictated that the poor, who were most numerous and multiplied most rapidly, should exercise 'restraint' in their marital relations, and so prevent starvation and social disruption. Artificial restraints of the kind which has now adopted his name were taboo, so was emigration; the answer could only lie in the self-denial of the working class.

The Malthusian truism itself can be given a prophetic ring capable of rousing near-hysteria; the prediction of famine in India, or famine in China, can lead people to generalise and raise the question, Why not world famine? This has been one reaction to Malthus. Yet another has been desperate opposition to the implications of his policy by a rising tide of humanitarian and socialist thought. It made charity to the poor a social sin, the introduction of social services a suicidal impulse. It confirmed a resistance to the idea of social welfare which was to delay for more than a hundred years free general access to the findings of medical and social science.

To many, Malthus became, not the kindly man he was, but an ogre representative of the blackest social reaction. Was he not also that father of an economic theory which argued that workers could never as a class become better off? He was, indeed, and he developed his theory in the name of Christian kindliness and humility.

Malthus has led not only to hysteria and opposition, but also to bewilderment. At bottom, the practical application of his truism rested on the notion that the output of food was limited by the quantity of land available—a factor which mesmerised British economists for at least three-quarters of a century. In practice, therefore, it has seemed that Malthus was wrong. Britain did not starve because of the world expansion of agricultural land, and because science brought higher yields from existing land. But the nagging fear has always remained that the returns from such developments would in themselves be limited. In time the extent of world cultivation will leave no margin for an expanding population. Scientific aids to higher productivity may fail. Through over-cultivation the world may become a vast dust bowl of the kind that previous civilisations and parts of our own have created. Will presumptuous man in the end be exterminated by the results of his own thoughtless ingenuity?

To extend the argument thus far is to return to the prophetic and lunatic fringe, but thoughtful people have repeatedly invoked some part of it in recent years. Pearson and Harper in their book *The World's Hunger* (1945) warned us that Europe's dependence of imported food in a world where world trade in foodstuffs may decline may ultimately place it in danger of overpopulation. Lord Boyd Orr, as Director-General of the Food and Agriculture Organisation of the United Nations, found it necessary to predict that the world was rumbling to destruction. Last year's president of the British Association, Prof. A. V. Hill, has expressed the dilemma in which the present-day scientist may find himself in relation to improving social conditions in areas where population already presses on food supply. In essence the dilemma he outlined was near to that of Malthus. Malthus was afraid that social services might worsen the lot of the poor by increasing their numbers; Prof. Hill is afraid that the application of science in such a country as India might more easily lower death rates than increase food supply, thus making population pressure more, rather than less severe. He thought fit to ask whether, in such circumstances, and in the name of humanitarianism, the scientist was justified in giving of his best in such a case. (Prof. Hill's presidential address was printed in DISCOVERY, Sept. 1952.)

Are countries, continents or the world itself doomed to starvation? A relatively few would answer a definite 'yes'. a relatively few a definite 'no'; the majority would most probably vacillate between these two contending views. For the most part, both the yeas and the nays would speak without evidence. In present circumstances it is highly likely that famine will strike some country or another from time to time, because of the high vulnerability of certain areas to natural calamities such as drought and bad harvests. But there is no clear evidence either that permanent and unavoidable starvation will ultimately wipe out mankind or even small sections of the human race, or that science will make such a catastrophe impossible. It is just as sensationalist to predict disastrous famine as it is complacent to argue that "God will provide", or to state that the scientist has only to be challenged and will automatically produce the solution to the problem. Yet the sensationalist and the complacent continue to revile each other.

What is needed is a sober appraisal of the facts about the world food position, and of the chances which science offers in the fight against famine. Such an appraisal would necessarily be a complex one. Famine can be avoided either by controlling population increase or by increasing food

REV. T. R. MALTHUS (1766–1834).

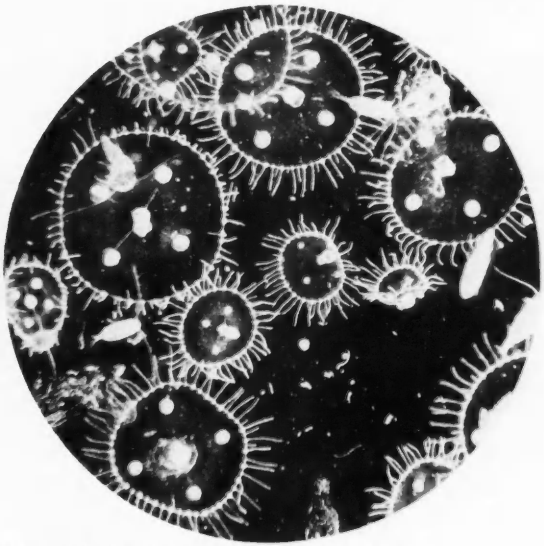
supply. The logical aim of any policy designed to prevent famine would be to ensure, as Malthus indicated, that food and population should march in step, with the further proviso that they should balance at the most adequate diet available at any one time. The achievement of such an aim is a combined operation on a world scale but on limited fronts—a combined operation in the sense that its weapons are not only those of physical science, but of economics and sociology; it would have to be an operation on limited fronts because variations in the natural, economic and social pattern of life make each area a separate problem in itself. It is relatively easy to talk of population control in the western world; readers of Evelyn Waugh's satirical extravaganzas can readily imagine the fantastic results that could emerge through using the same arguments in other countries with different social and educational backgrounds. It is easy to talk of increasing land productivity or of cultivating deserts, but the problems involved in this are not only scientific, but also *economic*—where is the money to come from?—and *sociological*—how are local populations to be fitted into the resultant new pattern of social life?

Parts of the foundations of this combined operation are well laid: the whole foundations are, however, nothing like complete. On the purely factual side, we know the areas in which population at this moment presses most hardly on food supply. We are tolerably well acquainted with the facts of national population growth. We have made a beginning to land use surveys. We know that crop and animal yield have been increased vastly since man first began systematic husbandry, and that improved techniques have brought marginal lands under the plough. We are no doubt justified in assuming that they will continue to do so in the future—but at most this optimism should be a sober one. We have wide knowledge of the soil of only a small fraction of the world's area. Who knows what problems lie in store for the scientist concerned with increasing the fertility of other lands? If the best scientific advice was taken in the Groundnuts Scheme, the outlook looks bleak; if elementary information like that of rainfall figures is not yet available, as was the case in the Groundnuts Scheme (we are told), just how much can the scientist reasonably do? In terms of percentages, even if we assume that attempts to restrain the growth of world population are without much chance of success, we are asking that overall food supply should increase at about 1·5% per annum plus an addition for improvement of nutritional standards. Fortunately the greatest rate of increase of population is felt not in Asia, but in the New World and Oceania, but the small figure of increased food production required may easily belie the difficulty of the task of hitting that target. A good deal of attention has recently been paid to the economics of developing backward areas, and incidentally it has highlighted the difficulties of obtaining the right kind of technicians for the job. Adequate finance for economic development in backward countries, including those with population pressure, is not hopeful. Even less well explored is the sociology of development. Technical revolutions can only be carried out to the accompaniment of rapid social change. This is difficult to achieve without either extreme ruthlessness, or incredibly careful planning and organisation. If logic says that the pig is desirable to supply first-class protein, how is the Muslim to be persuaded to consume it without religious disruption? If fragmentation of holdings obstructs technical progress, how can it be corrected; and, if fragmentation is corrected, what happens to the existing pattern of family life?

Those who have come nearest to local problems of food and population treat the chances of success most soberly. The Colombo plan does not reckon on raising the Indian standard of living for many years. Professor Hill is doubtful enough about the speed with which science can be brought to bear on Indian problems to suggest that the situation poses a scientist's dilemma.

Professor Glass's volume, to which we can at length return, does not provide this kind of synopsis. What it does do is to put Malthus in his historical background (an admirable, though not a beginner's essay by Mr. Beales), and to give us some interesting information on the limitation of population growth (Professor Glass himself); then there is a rather narrowly economic and exceedingly condensed account of Malthus in the 20th century (Mr. Peacock), together with reprints of two Malthus documents and a long bibliography of the original population controversy. This book should feature on the scientist's bookshelf along with such volumes as:

*The World's Hunger* (1945), by Pearson and Harper.
*Rape of the Earth* (1939), by Jacks and Whyte.
*Our Underdeveloped World* (1953), by L. Dudley Stamp.
*A Thousand Million Mouths* (1951), edited by Le Gros Clark & Pirie.
*The White Man's Dilemma* (1953), by Lord Boyd Orr.



These pictures show the contrast between the appearance of dead specimens of planktonic animals and that of living specimens whose movement has been 'frozen' by the electronic-flash technique described by Dr. Wilson. FIG. 1 (*left*). This sample of plankton was preserved in formalin. It includes one *Obelia* medusa (resembling a jelly-fish, to which *Obelia* is distantly related, both animals belonging to the same phylum), one squat lobster larva and several copepods. Note how the preservative has made the tissues opaque; the animals have died in unnatural attitudes, and their shape is often distorted—this has happened to the *Obelia* medusa. FIG. 2 (*right*). A plankton sample composed almost entirely of *Obelia* medusae, which were swimming freely when this picture was taken. (Magnification, ×10.)

# ELECTRONIC-FLASH PHOTOMICROGRAPHY

**DOUGLAS P. WILSON**
*D.Sc., F.R.P.S.* Marine Biological Laboratory, Citadel Hill, Plymouth

Living, actively moving microscopic organisms have always been exceptionally difficult subjects for the photomicrographer but the invention of the electronic flash-tube (which gives high-intensity flashes of extremely brief duration) has recently enabled him to obtain good pictures where this had previously been almost impossible.

What this means in practice cannot be better illustrated than by a consideration of past and present attempts to portray photographically that largest of all assemblages of living things, the marine plankton.

The microscopic plants and animals floating, swimming and drifting throughout the immensity of the seas and oceans of the world, have during almost the whole of recorded history been unseen and unsuspected even by those, such as fishermen, whose livelihood ultimately depended on them. It is little more than a hundred years since attention was first drawn to the wonderful minute life in the surface waters of the sea and it was as recently as 1887 that the word 'plankton' was first used. The then strangely unfamiliar forms of life taken in finely woven tow-nets and examined through the microscope were depicted, though often inadequately, with pencil, pen and brush: photography was scarcely used at all for the purpose until the opening years of the present century. Inevitably most of the early photographs were of dead specimens. The brightest lights and fastest emulsions of those days were inadequate to record satisfactorily these rapidly gyrating, swerving or jerkily swimming animals. Thus we find in the books of the period good photographs of dead plankton but very rarely any of living plankton organisms. Whilst some pictures of preserved plankton give a fair idea of what living plankton looks like, the glassy transparency of many species, their normal postures and sometimes even their proper shapes are lost at death. Here was a challenge to the nature photographer: a great community of strange and often lovely creatures still to be revealed by photography to the world at large.

The writer of this article has for long been deeply conscious of this challenge, but for years it was scarcely possible to obtain photographs of living plankton organisms unless they kept still for appreciable periods, which most of them did only when dead. By about 1935 a few research workers, using complicated apparatus, had indeed succeeded in photographing alive a small number of species in which they were specially interested, but no one, apparently, had yet obtained or made serious attempts to obtain a representative series of pictures. There was no standard apparatus which took care of all the problems connected with focusing and exposing on rapidly moving objects, or with the intense light source needed and the heat it produced. At that time there were several possible ways of dealing with these difficulties; the writer overcame them with an odd assembly of microscope and camera parts with which several pictures of freely swimming plankton animals were obtained. A camera, with a shutter but without a lens, was fixed above a microscope. An image of

the object to be photographed was projected by the eyepiece through a right-angled prism (placed just above the eyepiece, between it and the shutter) on to a ground-glass screen at one side, where it could be focused. For this a 60-watt opal lamp gave sufficient light without too much heat. The photograph was taken by pressing a foot-switch; instantly the prism swung to one side clear of the space between eyepiece and shutter; at the same time one substage mirror was substituted, electrically, for another reflecting light from a photo-flood lamp that lit up when the foot-switch was depressed. Then the shutter opened for a fraction of a second to make the exposure. Unfortunately this equipment, while practical, was cumbersome and not easy to keep in adjustment, it was therefore soon dismantled. The principles employed would still be useful in a well-constructed and compact apparatus.

In some ways it was a backward step to narcotise the plankton before photographing it. However, some years after ceasing to use the method described in the last paragraph, it was found that many plankton animals when put into a 7% solution of magnesium chloride in fresh water become immobilised, in natural postures and without loss of transparency. (Some species can even be returned to sea water to continue their development and be narcotised and photographed again at later stages.) The narcotised subject was gently held in a Rousselet compressorium* to inhibit drifting during an exposure which was often as long as one second. An eyepiece attachment camera with a side observation-tube allowed the subject to be watched before and during the exposure. This method of narcotisation is not suitable for all plankton organisms. It does not stop, for example, the beat of larval cilia which, therefore, at these relatively long exposures give blurred images in the photograph; this, however, is much as they normally appear to the eye. It was found unnecessary to narcotise certain types of sea-urchin and brittle-star larvae for they often showed no movements at all for short periods when gently restrained by the compressorium.

After the war electronic flash-tubes became available. Today they are in common use for obtaining still pictures of objects in rapid motion. In tubes of normal type, produced for the ordinary photographer, the flash takes place inside a coiled tube and as a light source for microscopy is too widely spread for direct use. To meet this difficulty R. H. J. Brown introduced the use of a special tube, in which a concentrated flash can be caused to occur at a position where a constant arc gives light for observation and focusing. However, a method of using the normal tube, devised by the writer before the special one was available, can be adopted by anyone possessing ordinary electronic-flash equipment.

The arrangement of the apparatus is indicated in Fig. 3. A piece of finely ground glass, polished side uppermost, leans at about 35° against a flash-tube (Mullard LSD3) placed horizontally before the microscope mirror. This ground glass diffuses and evens the light from the flash and a portion of it can be used as a satisfactory source of illumination for the microscope. The polished upper surface reflects light from a 60-watt opal lamp above it; by this light the subject is watched and focused. For dark-ground illumination, which has proved more generally satisfactory than direct transmitted light, the lower lens of an Abbé sub-stage condenser with central stop is used. The living plankton, or single organism in filtered sea water, is contained in a shallow rectangular dish made from a selected sheet of glass with four strips of thick glass cemented on to form the sides; there is no cover glass. Above the objective is a small iris diaphragm (Davis's shutter) which when partially closed increases the depth of focus. The eyepiece projects the image into a microscope attachment camera (Reichert) with a fixed prism that reflects a small fraction of the light into a side observation-tube provided with cross-wires on which the image may be focused. Above the prism is the camera shutter, the cable release from which is clipped into an electrically tripped home-made synchroniser connected to a foot-switch. When the foot-switch is depressed it first puts out the viewing light (60-watt lamp) and then trips the synchroniser. The latter ensures that the flash takes place while the shutter, set at one-tenth of

* A screw-device for raising or lowering a cover-glass above a glass plate, so that any small organism may be held between them.

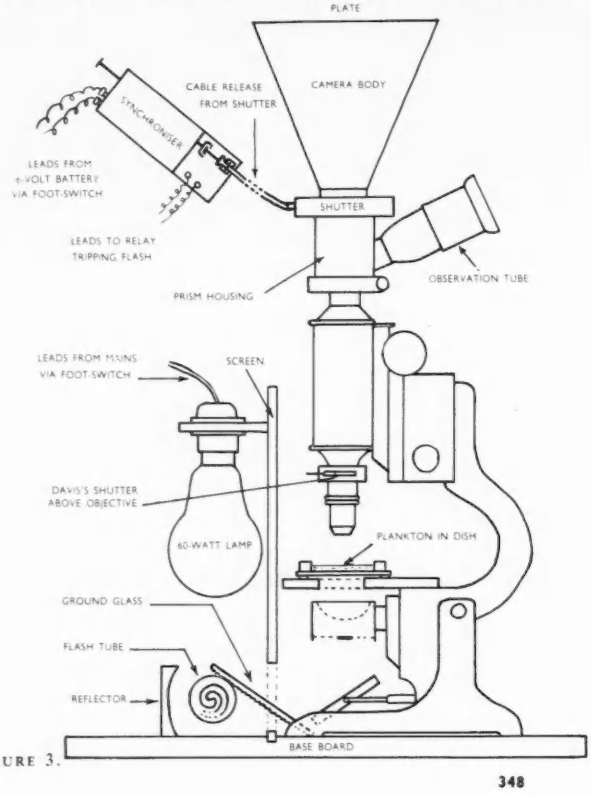
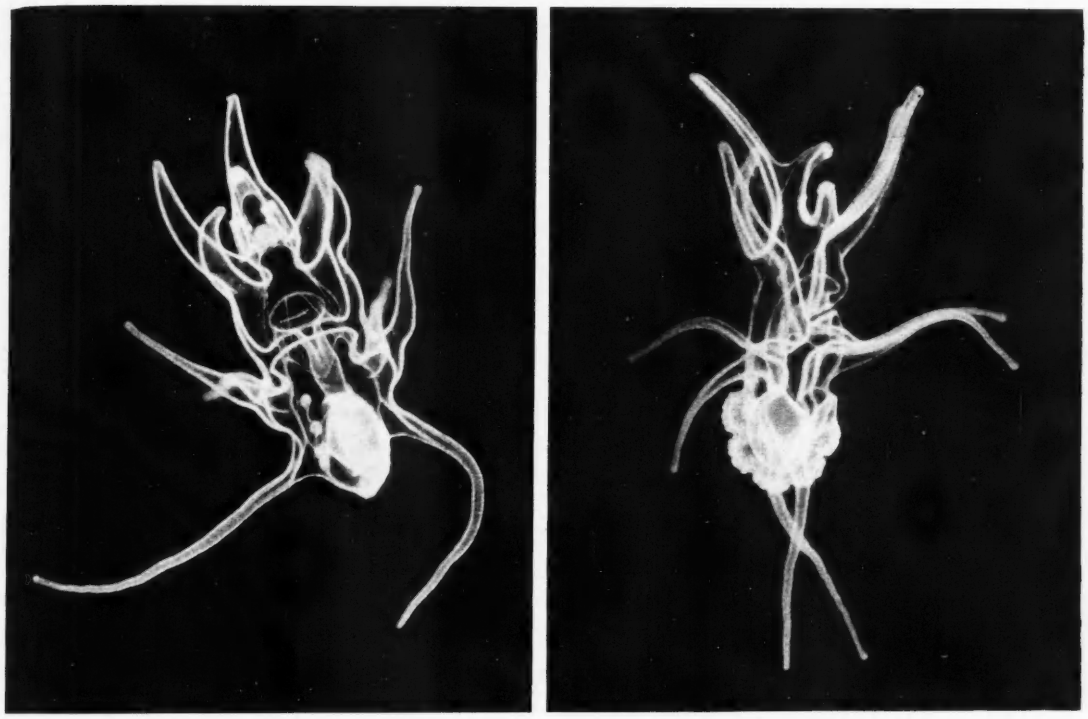



FIGURE 3.



Two electronic-flash pictures of the larva of the Common Starfish (*Asterias rubens*). FIG. 4 (*left*). Ventral view of larva. The long contractile processes carry many short fine cilia by means of which this extremely graceful larva swims. FIG. 5. A lateral view of the same larva. The body of the future starfish is clearly visible as a three-quarter moon-shaped structure with five well-marked lobes—the rudiments of the five arms which the adult starfish will have. (Magnification, ×20.)

a second, is open. The flash circuit is triggered by a 6-volt relay connected to the synchroniser, otherwise there is nothing unusual about it. The use of a foot-switch leaves both hands free to move the dish and to focus. Since early 1949, hundreds of exposures have been made with this apparatus and many types of plankton and many species of plankton organisms have been successfully photographed. The examples shown have been selected to demonstrate the ability of the electronic flash to 'freeze' rapid movements, such as those made by beating cilia (the duration of the flash is of the order of $\frac{1}{3000}$ sec.). Parts of the organisms that are blurred in the pictures are so because they are above or below the plane of sharpest focus.

The electronic flash has solved most problems connected with subject movement and camera vibration but the difficulty of obtaining sufficient depth of focus remains. Most microscopic organisms can only be rendered sharply all over if the magnification is so low that important structures are barely visible. In practice it is necessary to choose as low a magnification as will give an image on the plate sufficiently big to enlarge well, and to choose a focus which gives the best overall representation. This can be difficult with an active animal and 'near misses' may be exasperatingly frequent. Some forms, too, make good pictures only when seen in precise lateral, dorsal or similar aspects. A crab larva, for instance, is a confusing object from almost all view-points except the lateral, but to catch a particular specimen in the desired position when it is swimming freely in a dish can be well-nigh impossible. Such subjects are better narcotised, for the picture so obtained will be practically indistinguishable from a lucky shot of an unhampered specimen. This is true also of many copepods in dorsal view, and of crustaceans generally, but it is another matter altogether with molluscan veliger larvae and some other ciliated types. Most veligers expand and swim only in a fair depth of water, under favourable conditions, and like some other sensitive species contract when attempts are made to narcotise them. Thus the technique must be varied according to the organism being photographed. Perhaps most difficult of all is to obtain good pictures of concentrated plankton showing many organisms all in focus at once. Some early photographs of preserved plankton showing a great variety of species in the same picture have still not been bettered for use as illustrations of seasonal types of plankton.

## READING LIST

Brown, R. H. J., "Flash Cinematography", *The Photographic Journal*, 1952, **99B**, 130–33.

Wilson, D. P., "Photography and the work of the Marine Biological Laboratory", *ibid.*, 1937, **77**, 176–84.

# PLANT HORMONES

PROF. S. C. HARLAND
F.R.S.
Professor of Botany, University of Manchester

The word 'hormone' has now got into the vocabulary of the man in the street via the daily press, though not with any precise connotation. It is indeed difficult to talk about a subject without defining it, so I shall begin by being a little historical.

The term 'hormone' was minted in 1902 by Baylis and Starling, and it is derived from a Greek word meaning "I arouse to activity". Hormones denote chemical substances secreted by the endocrine glands which, when carried by the blood-stream to another organ, affect the functioning or activity of that organ.

Hormones have also been thought of as "chemical messengers". What do they do? To answer this question we must realise that all animals possess certain tissues and organs performing different functions, and carrying on special activities. The entire body has to work as an integrated and harmonious entity. No one part or tissue has to get out of step. Organs and tissues must therefore in some way be subject to a system of co-ordinating controls. These controls are, so far as animals are concerned, of two kinds. There is first the nervous system, which "may be likened to an intercommunicating network of telegraph wires centring in the brain, spinal cord and ganglia". Second there is a complex system of hormones or chemical messengers emanating from the endocrine glands which, by altering the activity of an organ, also affect the activity of others. The hormones act as a sort of balance wheel to enable the metabolic processes of the organism to function in an optimum way, and also to buffer or to minimise the evil effects of violent fluctuations of the environment. It will be sufficient to mention one or two animal hormones. Adrenalin is a hormone secreted by the adrenal glands. In periods of stress brought on by fear, rage or hunger, there is a discharge into the blood-stream of a much larger amount of this substance than usual. There is a rise in blood-pressure and a general mobilisation of bodily forces which enable the organism to meet the emergency. Insulin, which controls sugar metabolism, is the hormone secreted by the pancreas.

Animal hormones have now been studied for fifty years, and a great deal is known about the chemical and physiological properties of the thirty or more which have so far been identified.

A plant is also an association of different tissues and organs which require the same kind of co-ordination as we have seen to be necessary in animals. Plants have no nervous system and any co-ordination must therefore be through other mechanisms. It can be shown that there are in plants chemical substances which are formed in one part of the plant; they pass to other parts; they produce special growth effects, and they are thus entitled to be known as plant hormones.

## HORMONES AND ROOT GROWTH

An example of hormonal regulation in a plant is provided by the relationship between roots and leaves. By means of special techniques it is possible to grow excised roots in an aseptic culture medium. If this medium contains the right substances in the right amounts, these isolated roots grow as fairly normal roots. The medium first employed was one containing a complete array of mineral salts, with added sucrose, to supply the carbohydrate normally transported from the leaves to the roots. In successive transfers of flax roots to fresh media it was found that growth became poorer with each successive transfer. The roots needed something for growth which they were either not getting at all or which they were making in too small an amount. The necessary substance proved to be the well-known vitamin thiamine, and it was needed in the very low concentration of one part to ten million. When supplied the roots grew well. The nutritional requirements of tomato roots are somewhat different, and vary somewhat from strain to strain; some strains need not only thiamine, but also pyridoxine, nicotinic acid, or both these substances.

How does the root obtain its supply of thiamine and other necessary substances? It can be shown by some simple ringing experiments that in the tomato plant thiamine accumulates above a stem girdle between the root and the stem, and also above rings at the base of the leaves.

Absence of thiamine from the nutrient solution produces characteristic symptoms. Cell division slows down and finally ceases. Thiamine is therefore a factor influencing cell division. It is also a factor influencing respiration. Pyridoxine is concerned with the synthesis of amino-acids; nicotinic acid has to do with respiratory enzymes. All three substances thus play an essential part in the biochemical economy of the plant.

It has been known for many years that most animals including man require thiamine and other vitamins of the B complex as essential constituents of their food. These vitamins are made by plants, not to prevent deficiency diseases in animals or ourselves but for their own growth and well-being.

## GROWTH OF LEAVES AND STEMS

Just as there are root growth hormones, there are also *leaf growth hormones*. If, for example, immature leaves of the pea plant are excised and placed in a nutrient medium containing the usual mineral salts and sugar, they grow very little. But if the amino-acid adenine is added growth is promoted. Adenine thus functions as a leaf growth hormone in the pea plant. When tried with leaves of certain cereals, however, it was without effect. It is therefore likely that different species of plants need quite different substances to play the role of leaf growth hormones.

*Stem growth hormones* comprise a series of hormones which are synthesised in the apical bud or young expanded leaves and then transported to the elongating parts of the stem. If you take a section from the growing region of a pea plant which has been kept in the dark, and place it in a

nutrient solution containing mineral salts and sugar, there is practically no growth. But if a small amount of the substance IAA (*indoleacetic acid*) is added, there occurs a very rapid elongation of the excised section.

This substance, IAA, is therefore proved to be instrumental in speeding up the growth of stem tissue. It works also in very low concentration, since only about ten parts per million are required to bring about the effect. Growth substances such as IAA and related compounds are known as *auxins*. Auxins are concerned not only with stem elongation but also with other growth co-ordinating processes within the plant. The main point to bear in mind is that the hormone principle is evoked to bring about a correlated and harmonious integration of the whole plant.

## ARTIFICIAL CULTURE OF PLANT EMBRYOS

We have so far seen that the growth of a plant organ such as the root partly depends on minute quantities of chemical substances transported from other parts of the plant. The techniques of tissue culture enable us to identify some of these substances.

It is now possible to grow the excised ovaries of tomato in a culture medium. The tiny ovaries are excised shortly after pollination and placed in a medium supplemented by the juice of either green or red tomatoes. This juice presumably contains substances necessary for growth which are probably transported to the ovary from other sites, but neither the sites nor the chemical nature of the substances are known. Lately it has been discovered that the substance NOA (*naphthoxyacetic acid*) acts as an adequate substitute for tomato juice. The cultivation of fruits in artificial media obviously has exciting possibilities for the future.

Minute and only partly developed embryos can be caused to develop by using an artificial culture medium supplemented by additional substances in low concentration. These include some vitamins of the B complex such as thiamine and pantothenic acid. Other unidentified compounds are known to be contained in yeast extract, malt extract, and coconut milk. The growth of mature embryos can be speeded up by addition to the medium of thiamine, biotin, nicotinic acid, and other special substances.

## WOUND HORMONES

When wounds in plants begin to heal the formation of new tissues appears to be started by particular chemical substances liberated from injured cells. These wound-produced substances may also be counted among the plant hormones. If a potato tuber is cut, the surface soon becomes covered by a layer of corky cells, but if the injured surface is washed just after cutting the layer of healing cells is not formed. One wound hormone has been isolated from injured bean pods. It is known as *traumatic acid*. It is not effective with tissues other than those of the bean and it seems likely that different species of plants are characterised by wound hormones of chemically diverse types.

To sum up: the growth of a plant is controlled and integrated by many growth hormones, each produced in a particular organ and transported to other organs or tissues. A knowledge of these substances has thrown light on such old questions as the reason for the bending of plants towards light and the response of plants to gravity.

## AGRICULTURAL APPLICATIONS

It will have been noticed that the substances which we have postulated as fulfilling the original definition of a growth hormone are not usually thought of in this sense so far as the animal world is concerned. The animal physiologist would not regard thiamine as a hormone, nor would he consider the new antibiotics which promote growth in animals as falling within this category. The term plant hormone is now used in a much wider sense. Two American investigators define a plant hormone as follows: "a hormone is any organic chemical substance, naturally occurring or synthetic, which in very low concentrations affects growth or metabolism—at the site where naturally produced, or applied, as well as at sites to which it may be transported". If I discussed plant hormones in the restricted sense of the earlier use of the term, I should not be able to refer to the technological applications of what should more properly be called growth-regulating substances, or more simply growth factors. For out of purely academic investigations on the phenomena of growth, largely carried out by plant physiologists, have emerged discoveries of the greatest importance to agriculture and horticulture. We are now embarking on a complete chemical overhaul in agricultural practice, and I hope now to outline some of these new developments.

The hormonal function of IAA (indoleacetic acid) was first discovered in 1934. It was the first naturally occurring hormone to be identified, although Majima and Hoshino of Japan had synthesised it as early as 1925.

In 1935 Zimmermann and Wilcoxon announced the discovery of other organic synthetic substances with hormonal properties. The most important of these were: NAA (naphthaleneacetic acid); and IBA (indolebutyric acid).

In 1938 Levine established that another substance behaves as a hormone: NOA (naphthoxyacetic acid).

In 1942 Zimmermann and Hitchcock reported on the effects of yet another synthetic compound on plant growth: 2, 4-D (2, 4-dichlorophenoxyacetic acid).

In 1943 Zimmermann found that 2, 4-D induced hormonal responses in plants. These four synthetic hormones, all discovered within a period of eight years all produce hormonal responses, but to different degrees. Their discovery and commercial possibilities led to an enormous expansion of research in which the principal roles have been played by the research laboratories of the chemical industry, and by plant physiologists working in government experimental stations, in research institutes and to a minor extent also in universities.

The list of synthetic substances with growth-regulating properties which can be used in agriculture and horticulture is now very large, and it would serve no useful purpose to refer to any of them individually. I must, however, stress the fact that twenty years ago the gardener or farmer of inquiring mind knew nothing about plant hormones. It is only in recent years that their exploitation has become what our American friends like to call a multi-million-dollar industry.

FIG. 1. Propagation of apple rootstock using a plant hormone. *Top row:* Untreated cuttings. *Bottom row:* Cuttings showing marked rooting response to indolebutyric acid (IBA).
(*Copyright, East Malling Research Station*)

It will be of interest to enumerate some of the things which plant hormones can do, and for which they are used at the present time:

1. Control weeds.
2. Cause flowers to remain on a tree.
3. Cause flowers to drop off.
4. Produce fruits without pollination.
5. Prevent the formation of fruit.
6. Cause more fruits to develop.
7. Cause total or partial elimination of fruits.
8. Produce earlier fruits.
9. Produce later fruits.
10. Produce seedless fruits.
11. Produce fruits with more seeds.
12. Induce root formation (on cuttings).
13. Prevent the sprouting of tubers (potato).
14. Cause defoliation.
15. Enable difficult plant hybrids to be made.

This list is a formidable one, and it will be readily seen that these practices do represent an enormous advance in agricultural techniques and that we are veritably in the middle of an agricultural revolution. The late Sir Daniel Hall once said that there were only two major discoveries which science has made to agriculture: one of these was the discovery of artificial manures; the other was the discovery of the laws of Mendelian inheritance. I think that it may now be safely said that the discovery and proper use of growth-regulating substances is a third major contribution which science has made to agriculture.

## WEED CONTROL

It will have been noted that the discovery of the hormonal properties of the substance 2, 4-D took place in 1942. By 1948 twenty-seven and a half million pounds of 2, 4-D were being manufactured annually for agricultural use in the United States, more especially for weed eradication or control. This substance is especially toxic in certain concentrations to broad-leaved weeds, and by spraying it inhibits the growth of these. Applied to the soil it prevents the germination and development of weed seedlings. The average rate of application is about one pound per acre, and it may therefore be estimated that in 1948 about twenty-five million acres were treated in the United States. The use of 2, 4-D is favoured by the fact that grasses and cereals are quite resistant except when young, and as broad-leaved dicotyledons are very sensitive, this enables cereal crops and lawns to be freed from bad weeds of this type with relative ease; 2, 4-D is so potent that a few pounds of the chemical would be enough to affect the growth of the whole of most dicotyledous crops in this country.

## PREVENTION OF PRE-HARVEST DROP

The second largest outlet for the use of plant hormones is for the prevention of pre-harvest drop in fruit. The weed-killing substance 2, 4-D has also been used for this purpose, and also for accelerating the ripening of green bananas and apples. There are now many proprietary products on the market, but chemically they all appear to be naphthaleneacetic acid (NAA) or a new substance, 2, 4, 5-trichlorophenoxyproprionic acid (2, 4, 5-TP).

Pre-harvest drop of apples has been a headache for the fruit grower for a long time, and one of the first uses of hormone sprays was to reduce this source of loss. NAA is applied as a spray at a concentration of ten parts per million or as a dust at 0·1 per cent. The time of application is just as soon as much dropping becomes evident. The substance 2, 4, 5-TP is effective in controlling fruit drop and is also said to improve colour. Varietal differences affect the efficiency of the particular chemical substance used; NAA does not work very well with some varieties whereas 2, 4-D has been a success.

Hormonal control of fruit drop in oranges is now a well-established practice in California. This is of great practical importance, as fruit drop formerly caused great loss of crop—amounting to as much as 25% at the end of the season. Following the lead of the apple growers, spraying with NAA was first tried, but proved useless. However, the alternative substance 2, 4-D was found to work. It is applied as a water spray in the low concentration of only eight parts per million. In an oil-water emulsion the even lower concentration of four parts per million has been found practicable.

The problem of how to deal with too much fruit in apples and other fruits has also been the subject of experiment. Hand thinning is of course an expensive operation. Here the same substance NAA is used at low concentration, and is applied at the flowering stage or shortly after.

## HORMONES IN HORTICULTURE

(*a*) Prolonging the blooming period.

The use of hormones in horticulture is now widespread for a great variety of purposes. They will prolong the flowering period of such trees as the flowering cherry (*Prunus* spp.).

In periods of warm weather the flowers open rapidly and shed quickly, and spraying with NAA or allied compounds will cause the flowers to stay on the trees much longer. The spray should be applied when most of the flowers are fully open. Not all ornamental trees respond to treatment. Azaleas do not respond, nor do crab-apples, flowering quinces or magnolias.

(*b*) Preventing holly leaves from dropping.

NAA is highly effective at a concentration of twenty parts per million.

(*c*) Preventing fruit production in flowering trees.

Several compounds are used, depending on the species involved. NAA works with some species (e.g. horse chestnut) but not with others (some types of purple crab-apple).

A compound so far not mentioned, maleic hydrazide, was found to prevent the fruiting of the maidenhair tree (*Ginkgo biloba*).

(*d*) Rooting of cuttings.

It is common knowledge that some plants can be grown very easily from cuttings and others not at all. Hormones can be used to hasten rooting and to increase the number of roots formed in a given time, but they will not cause roots to form on material that normally does not root, nor can the use of hormones replace horticultural skill. There are many synthetic products in commercial use and these are mainly IBA (indolebutyric acid) and NAA (naphthaleneacetic acid) together with related compounds.

(*e*) Producing fruits without pollination.

If you plant a holly tree in your garden you may not get any fruits. This is because some trees are males and cannot fruit, or because the tree is a female and there is no male near at hand to supply pollen. A hormone spray will induce abundant setting of fruit, not only in holly, but also in tomatoes, fuchsias, and many other plants.

Seedless tomatoes can now be produced to order by using a large range of compounds. Indolebutyric acid is recommended, but there are now many others.

On a small scale spraying can be done with a hand atomiser. The spray is applied when the flower is fully expanded and repeated applications are necessary throughout the season at intervals of about a week.

(*f*) Preventing potato and stored nursery stock from sprouting.

Large-scale users of potatoes have suffered heavily in the past from premature sprouting. The potatoes are usually stored in a temperature of 40° F. or somewhat higher, and much sprouting is evident after a few weeks' storage at this temperature. Hormone treatment can be used for inhibiting the growth of sprouts. A good method for the small gardener is to use a handful of confetti impregnated with hormone to each bag of potatoes. The hormone used is naphthaleneacetic acid in the form of its methyl ester.

It is often necessary to store various plants such as young fruit trees and roses for relatively long periods of time, especially in spring. Many plants sprout after a short rest period and use up their food reserves. Then when planted out they either fail to survive or grow very slowly. The same hormone which is used for potato sprouting can also be used for roses and young fruit trees.

## HORMONES AND THE PINEAPPLE INDUSTRY OF HAWAII

The pineapple industry of Hawaii is probably the most efficient agricultural large-scale enterprise in the world. It is therefore not surprising that the fullest advantage is taken of the immense possibilities of plant hormones for the control of growth.

Hormones are used to bring varieties into flower at convenient times. Some varieties are slower to flower and take as long as five years. An old practice was to smoke the plants by means of large bonfires, using tents to confine the smoke. The current practice is to spray with NAA at a concentration of about one ounce per acre using large power sprayers. Only one application is necessary. The advantage of uniform flowering is very great since before hormone spraying came into use, the crop extended over a period of several months. Now that the whole field can be made to flower at once, all the plants fruit over a very short period. Uniformity of fruiting means increased yields, and exact timing of picking in different fields is now possible. As soon as one field is finished another is just ready for picking.

An interesting sidelight is that NAA induces a very long and weak stem. Another hormone is used to counteract this. Spraying with beta-naphthoxyacetic acid delays the ripening of the fruit, increases its size, and at the same time strengthens the stem.

## USE IN MAKING DIFFICULT HYBRIDS

Hybridisation between varieties within a species is usually easy. Hybridisation between different species in a genus is more difficult and depends very much on the genus and on the species. Some species crosses are easy and others difficult or impossible.

One frequent cause of lack of success is the fact that even if one or two seeds do result from the application of pollen from a different species, the fruits drop off or do not mature. Or the pollen tubes grow so slowly that the flower drops off before fertilisation is effected. Many new hybrids, formerly considered to be impossible, have now been made with the aid of plant hormones.

Rick in California has even succeeded in crossing the tomato with a wild species of *Solanum* native to Southern Peru. He used the substance parachlorphenoxyacetic acid in a concentration of 0·01% in lanoline.

## THE FUTURE OF PLANT HORMONES

It will be apparent from the short account which I have given of the current position of the use of hormonal regulators of plant growth, that spectacular progress may be expected in the future. In my own field of interest, which is mainly that of breaking the present barriers to crossing representatives of different genera, it is apparent that we are in the beginning of a new era of untold promise. A large number of hitherto intractable species combinations have been made though few workers are employed in this field. The control of some important plant diseases and insect pests can best be done by incorporating resistance genes from allied species and genera. The scope of plant breeding is thus greatly enlarged by these new perspectives.

With regard to weed control it is likely that the newer methods of chemical and hormonal control will result in far-reaching changes in agricultural practice. The planting distance of maize at present is about 42 in. by 42 in.; the check row system has been evolved to permit of weed control, by cultivating both ways. If pre-emergence soil treatment could control weeds effectively—and we seem well on the way to this—the planting distance could be reduced, and the yield probably increased by a more intensive cultivation of the soil, permitting the use of more fertiliser.

From the standpoint of the plant physiologist it would seem that the characters of plants are not so fixed as was thought. If the flowering time of grasses could be delayed

FIG. 2. The hormone weedkiller MCPA has wiped out the poppies from the half of the field sprayed with it. Usually applied as the sodium salt; the more soluble potassium salt is now available.

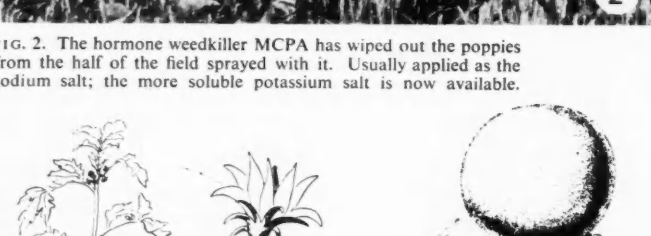

Flower after pollination
Fruit after 6 weeks growth on plant
Ovary at time of pollination
Tomato plant
Fruit after 6 weeks growth in culture

FIG. 3. (*above*). Artificial culture of tomatoes. This diagram indicates how an embryo tomato detached from the plant can grow into a full-size fruit in artificial media, which must include a growth hormone. (After Jansen.)
FIGS. 4–5. A fruit-setting hormone. In Fig. 4 the authors of the tomato flower have been removed: no fruit results. In Fig. 5 the emasculated flower has been sprayed with naphthoxyacetic acid. (*Figs. 2, 4–5 Plant Protection copyright*)

it might be possible to maintain a permanent leafy sward, and radically change the composition of the crop for feeding purposes.

Other modifications may be expected. Delayed flowering and quicker maturity may permit plants to be grown outside of their normal climatic zones, and the production of parthenocarpic fruits—seedless fruits—will certainly increase. Already almost the whole of the fig industry of California has gone over to seedless fruits, and this is the only industry which has so far done so. There is some evidence that hormone produced fruits may be different in chemical composition from those naturally set. It is reported that seedless tomatoes are sweeter.

At present the field of application of this new chemical knowledge is being restricted by lack of fundamental knowledge of the precise way in which they act. Additional uses will certainly be found for the new chemical substances which are now being turned out in ever increasing quantities.

All the facts which have been mentioned concern the phenomenon of growth—of the factors which control the velocity and regulation of cell division. A study of growth is an exploration of the most fundamental of the properties of living matter of the whole organic world. It is in this study that the points of view of workers in many varied disciplines will coalesce. Any new facts about growth in any organism may profoundly affect knowledge about man himself. The biochemistry of the behaviour of the excised roots of groundsel may seem unconnected with fundamental problems of human disease, but the biochemistry of life comprises an integrated and interlocking series of interrelated facts, and any fact about one organism may tie up in quite an unforeseen way with another fact about another organism. "They also serve who only stand and wait" applies to facts as well as to individuals.

(*This article contains the substance of Prof. Harland's Fernhurst Lecture to the Royal Society of Arts.*)

# Far and Near

### Atmospheric Pollution, Industrial and Domestic

The theme of Prof. O. G. Sutton's recent DISCOVERY article (July 1953) about "The Stack Problem of Atmospheric Pollution" came up at least twice during this year's annual conference of the National Smoke Abatement Society. Two speakers referred to the importance of ensuring that industrial effluents from chimney stacks are discharged at the best possible height to give maximum dilution and dispersal.

One session was devoted to the production and availability of the various smokeless fuels. The total tonnage at present produced is 37 million tons (most of it coke), of which only 5 million tons goes into homes. Thirty-five million tons of coal are used for domestic purposes. The smoke problem, stated a joint paper by Dr. F. J. Easton, G. E. Hall and I. Jacob, cannot be solved so long as bituminous coal is burnt in open fires, no matter how these are designed.

Availability of smokeless fuel generally limits the choice to gas coke, Welsh Dry Steam coal or the low-temperature cokes "Coalite" or "Rexco". To ensure the correct quality, the gas coke sold for open fires has to be selected both as regards size and combustibility, and the name "open fire coke" is used in some parts of the country for purposes of identification. Hard coke can be suitably prepared for the open fire. Generally, however, hard coke is not sold in this market. This is also true for Anthracite, although in S. Wales many householders choose it in preference to other fuels.

The appliance now known as the improved open fire is necessary for burning Anthracite and gas hard cokes; all the other fuels can be burnt on the more widespread coal-burning appliances. Thus, without alteration of appliances the use of "Coalite", "Rexco" or Welsh Dry Steam coal will eliminate smoke.

From the national standpoint the newer appliances ensure a wider selection of fuels, and whenever a simple stool bottom grate is replaced either by an improved open fire with back boiler, a convector open fire or a convector open fire with back boiler, there is a considerable improvement in efficiency; up to twice as high for the first two types of appliance and to about 2½ times for the last type. The improvement in efficiency of the improved open fire without boiler or convection over the stool bottom grate has been questioned by a number of investigators recently who have shown by laboratory tests that when burning *bituminous* coal there is no increase in efficiency by changing to the improved open fire. It has been proved, however, that with smokeless fuels efficiency is improved and that the closer control of combustion with the newer grates can lead to fuel saving.

This paper gave costs for purchase and installation in eight cases where new and more efficient heating appliances replaced old domestic grates and cookers. The lowest figure quoted was £4 15*s*.–£5 10*s*. for a gas/coke fire. For supplying and fixing improved open fires in existing fireplaces (with a back boiler), the figure worked at £7 per installation for a large batch of conversions, totalling 1400 in all.

### Radio Industry Council's Premium Awards for Technical Articles

To encourage the publication of articles reporting technical progress in the field of radio, television and electronics, the Radio Industry Council awards every year a number of premiums to the writers of outstanding articles. Last year five 25-guinea premiums were awarded, one of them going to W. R. Stamp for his DISCOVERY article on *Underwater Television*, which we published in September 1952.

The panel of judges includes PROF. WILLIS JACKSON (Director of Research and Education, Metro-Vickers Electrical Co.); MR. P. D. CANNING; MR. W. M. YORK; MR. C. E. STRONG, and VICE-ADMIRAL J. W. S. DORLING, C.B., M.I.E.E. (Director of the Radio Industry Council). The panel will soon be meeting to consider articles accepted for publication this year in journals on sale to the public. Five copies of each article submitted should be sent to: The Secretary, Radio Industry Council, 59 Russell Square, London, W.C.1, not later than November 30. A leaflet giving details of the premium scheme can be obtained on application.

### Kalinga Prize for Interpreting Science: New Conditions

The conditions for the award of the Unesco Kalinga Prize have now been altered. It is now intended to award this prize as a mark of recognition for "*a distinguished career of public service in the interpretation of science*", whereas hitherto the prize was associated with particular books or articles. Candidates will be nominated by national associations for the advancement of science and national associations of science writers, whereas previously nominations were sent in by the "adhering organisations" of the International Council of Scientific Unions. The judges will be named by an international federation of science associations or by Unesco, instead of by I.C.S.U. The judges for 1954 are DR. CORTES PLÀ, DR. I. H. ABDEL-RAHMAN and M. PAUL GAULTIER. No individual nominations or applications can be considered.

### Ion Exchange Resins

B.D.H. has just published a second and enlarged edition of its booklet entitled *Ion Exchange Resins*. This includes a discussion of the general properties of these substances, and descriptions of the properties of the 'Amberlite' resins, and those produced by Permutit Co. Ltd. (the Zeo-Karb and De-Acidite series). Ninety references are listed. The booklet is obtainable on application to: B.D.H. Laboratory Chemicals Group, Poole, Dorset.

### Controlling the Red Spider

A new compound for the control of the red spider mite has been developed by Boots Pure Drug Co. Ltd. It is sold under the trade name of *Chlorocide* (*p*-chlorobenzyl *p*-chlorophenyl sulphide). This acaricide kills the eggs of the red spider, as well as the young mites. It is available both as a dispersible powder and an oil suitable for low-volume spraying.

With apples and pears a single spraying at the green to pink bud stage is effective for the whole season. For plums, two sprayings during June and July with a three- or four-week interval are recommended. Spray deposits remaining on fruit are non-poisonous to human beings, though they remain active against the mite for several months.

The red spider has become a major pest in orchards, probably because insecticides such as DDT have killed off its predators and parasites. In Essex, for example, it now causes more damage than capsid. Other useful acaricides which are used against it include lime sulphur, derris, parathion, azobenzene, and DNC (for the eggs).

### The Scientific Film Congress

Films from 23 countries were exhibited at the 7th annual congress of the International Scientific Film Association, which met in London from September 18 to 27 under the presidency of Mr. John Maddison of the C.O.I. Films Division.

It is only possible to mention here a few of the most interesting films. *Flammes du Soleil*, a French film which commemorates the work of the astronomer Bernard Lyot, contains some twenty examples of solar prominences in motion, speeded up about 600 times. It ends with a succession of explosions in the chromosphere, some of which reach a height of a million kilometres above the sun's surface. Much of the material in this film came from research film records made by Lyot and W. O. Roberts.

From Canada there came a remarkable film (using time-lapse, colour and the microscope) showing the development of a chick embryo within the egg. This was directed by J. V. Durden, who used to work with the late Percy Smith and is now the scientific film consultant of the National Film Board of Canada.

There were two outstanding nature documentaries in colour. These were *Life in the Soviet Arctic* from the USSR, and *From Blossom Time to Autumn Frosts*

by the noted Hungarian cameraman-naturalist Istvan Homoki-Magy. The American film *Out of the North*, another notable nature film in colour, dealt with the habits of American wild geese and ducks.

A British film, *Fish and the Seine Net*, showed the frogman diving technique and cinematography combined to yield important results in research into fisheries problems.

Besides the film shows there were special lectures and demonstrations. One session was devoted to the progress and uses of 3-D films. This was organised by Denis Segaller of the Shell Film Unit, who contributed the article about 3-D films to last month's DISCOVERY. The speakers included Nigel Spottiswoode, H. Dewhurst, and M. Bonnet who described a raster system which dispenses with the use of viewing glasses.

Various new 3-D films were shown, including one on crystal structure specially produced for this occasion, one on calico printing, and a 3-D animated puppet film from Holland.

Among the medical films was a French 3-D picture showing the removal of a gall bladder.

Another 3-D film was exhibited by B.I.S.R.A. who use this technique for studying the flow of gases inside furnaces.

### New Portable Fluoroscope

Nowadays fluorescent effects are commonly used to detect or identify particular materials. For instance, the presence of crude oil in the borings from a well may be detected during fluorescent inspection by oil prospectors. Minerals that are fluorescent may be identified by mineralogists in the course of a geological survey.

Metropolitan-Vickers Electrical Co. Ltd. has now put on the market a new and portable fluoroscope (Brit. Pat. 696,098), devised by Mr. J. W. Walley. A filter which absorbs visible light but passes ultra-violet light is used to provide u.v. radiation for viewing the fluorescent material in a closed compartment. The instrument eliminates the need to have a supply of electricity available, as is usually required with fluoroscopes.

### Appointments

PROF. F. A. PANETH, one of the world's leading experts on radiochemistry, has just retired from the chemistry chair at Durham University which he held in conjunction with the directorship of the Londonderry Laboratory for Radiochemistry. Aged 65, he now becomes director of the Max Planck Institute for Chemistry at Mainz.

After graduating at Vienna, he came to Britain in 1913 and worked in Frederick Soddy's laboratory at Glasgow University. He won early recognition for his delicate techniques of gas microanalysis, techniques which led him to the dating of meteorites and other objects by means of their helium content. His researches won him an F.R.S. in 1947.

His books include *Radio-Elements as Indicators* (1928); *Manual of Radioactivity* (with G. Hevesy, 1938); and *The Origin of Meteorites* (1940). His article in DISCOVERY (September 1948) on John Newlands and the Periodic System is worth attention for it showed how the Periodic Table could be brought up to date, taking in the trans-uranium elements and the other newly discovered elements with minimum disturbance to the traditional table.

His successor at Durham University is Prof. G. E. Coates. Born in 1917, he was educated at Clifton College and graduated at Oxford. Since 1945 he has been lecturer in organic chemistry at Bristol University. He has done research into corrosion and electrochemical problems, and has been associated with the Magnesium Metal Corporation and Imperial Smelting Corporation.

* * *

MR. W. J. C. LAWRENCE has been made acting director of the John Innes Horticultural Institution as from October 1, when the former director, Dr. C. D. Darlington, took up his post as Sherardian professor of botany, Oxford University. The announcement of the name of Dr. Darlington's successor is expected within a few months. MR. M. B. CRANE, who was second in command under Dr. Darlington, has also left John Innes, and is now attached directly to the A.R.C. as an 'inspector' of fruit research.

### Death of Dr. E. P. Hubble

The great American astronomer, DR. E. P. HUBBLE, died on Sept. 28 at San Marino, California, at the age of 63.

It was Dr. Hubble's observations which provided such impressive support for the theory of the expanding universe propounded by Holland's W. de Sitter during World War I.

A graduate of Chicago, he came to Queen's College, Oxford, as a Rhodes scholar. On his return to the U.S.A. he joined the staff of the observatory of Chicago University. The war brought him to Europe in the U.S. Army, and after demobilisation he went to Mount Wilson Observatory. His work on extra-galactic nebulae was of outstanding importance, and readers are referred to his two books, *The Realm of the Nebulae* (1936) and *The Observational Approach to Cosmology* (1937), for further details. He made further remarkable discoveries with the aid of the 200-in. telescope of Mt. Palomar.

Britain's Royal Astronomical Society awarded him their Gold Medal in 1940, and his old college at Oxford made him an honorary fellow in 1948.

### Terylene for France and Italy

Both France and Italy are to start production of 'Terylene' under licence from I.C.I.

I.C.I.'s plans for bigger British production are making rapid progress, and the building of the great new 'Terylene' plant at Wilton, in north Yorkshire, is up to schedule. This plant should be ready by the end of next year, and in production in 1955.

### A New Selective Weedkiller

A new liquid hormone selective weedkiller, 'Agroxone' 4, developed by Plant Protection, will be available to British farmers in 1954. This new weedkiller is based on the *potassium* salt of MCPA, which will replace the *sodium* salt—previously the standard form of MCPA selective weedkillers.

'Agroxone' 4 is more concentrated, and the active agent is more soluble than most other forms of MCPA. Farmers will find it somewhat easier and quicker to mix.

The purity of the new product has an interesting implication in connexion with glasshouse crops. Occasionally in the past less pure commercial formulations of MCPA have, when applied near glasshouses, caused a certain amount of taint in tomato crops. This was caused, not by the active weedkiller in the chemical, but by the small proportion of chlor-cresol impurities in the products. The new 'Agroxone' 4 contains a very appreciably smaller amount of these tainting chemicals.

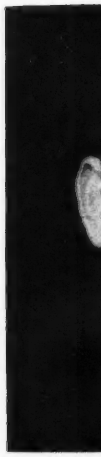
### Night Sky in November

*The Moon.*—New moon occurs on November 6d 17h 58m., U.T., and full moon on November 20d 23h 12m. The following conjunctions with the moon take place:

| November | | | | |
|---|---|---|---|---|
| 3d 09h | Mars in conjunction with the moon, | | Mars | 6° N. |
| 5d 03h | Venus | ,, | Venus | 7° N. |
| 8d 01h | Mercury | ,, | Mercury | 2° N. |
| 22d 19h | Jupiter | ,, | Jupiter | 3° S. |

In addition to these conjunctions with the moon, Venus is in conjunction with Saturn on November 14d 04h, Venus being 0·9° S., and Mercury is in conjunction with Venus on November 23d 17h, Mercury being 1·2° N.

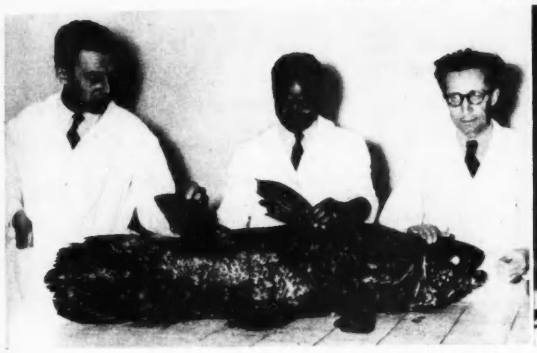
*The Planets.*—Mercury sets half an hour after sunset on November 1, and is in inferior conjunction on November 14, during which time it is too close to the sun to be seen. On November 30 it rises at 5h 45m, nearly 2 hours before sunrise, and can be seen for a short time in the eastern sky but owing to its fairly large southern declination it will not rise very far above the horizon before sunrise. Venus is a morning star, rising at 4h 50m, 5h 30m, and 6h 20m, at the beginning, middle, and end of the month, respectively, stellar magnitude −3·3, the visible portion of the illuminated disk varying from 0·93 to 0·97. Mars is a morning star, rising at 3h approximately during November. At the beginning of the month it is midway between β and η Virginis but owing to its easterly movement it is close to θ Virginis at the end of the month. Its stellar magnitude is 1·9 throughout the greater part of November but towards the end of the month it becomes a little brighter and continues to increase in brightness for the remainder of the year. Jupiter rises at 18h 55m, 17h 55m, and 16h 50m, on November 1, 15, and 30, respectively, stellar magnitude −2·3. Towards the end of the month the planet is close to

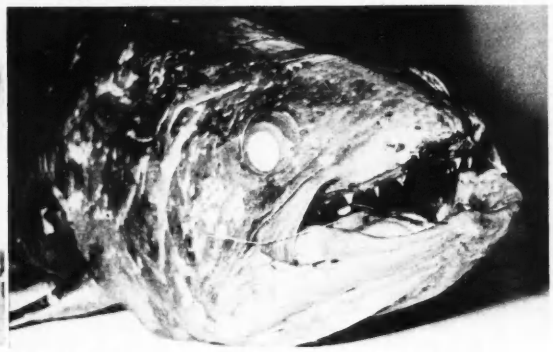


*Sir John become ac*

*Prof.*

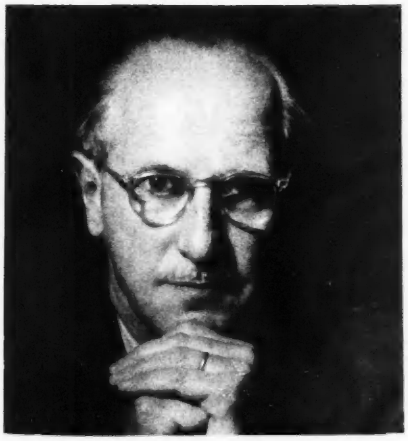
# NEWS IN PICTURES



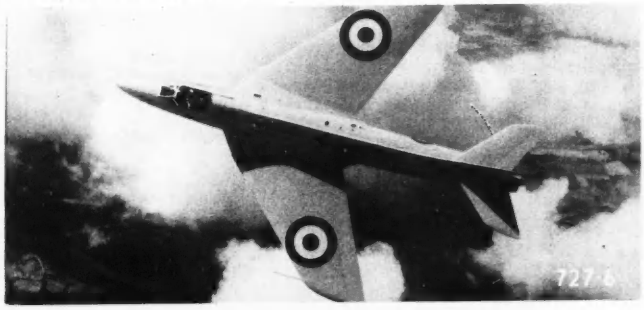


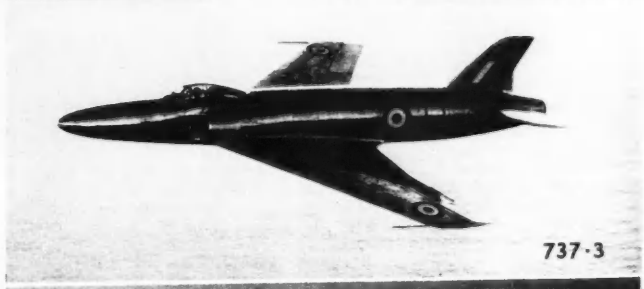
*The finest specimen of a coelacanth so far obtained was caught by native fishermen on September 24 in the Comoro Islands off the East African coast. A French scientific expedition had the fish flown to the Madagascar Institute of Scientific Research at Tananarive, where both these pictures were taken. This fish, a male weighing 90 pounds, is 52 inches long. It is in far better condition than the specimen of Malania caught last December in the Comoro Islands. It is reported that in the interval between these two captures another coelacanth was hooked but got away after a struggle.*

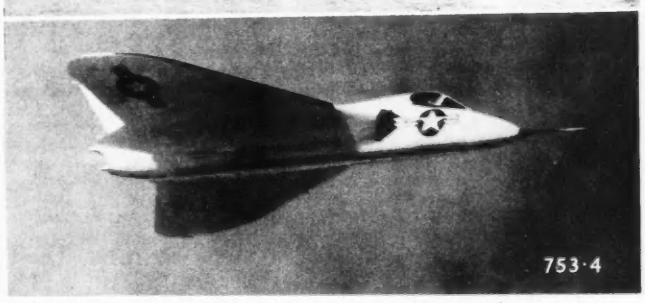
*Sir John Cockcroft is to leave Harwell and become head of the Cavendish Laboratory, according to newspaper reports.*



*Prof. F. A. Paneth;* see "*Appointments*".






*This autumn witnessed three attempts on the world air speed record. Early in September Neville Duke achieved 727·6 m.p.h. in a Hawker Hunter. This record was beaten on September 25 by Michael Lithgow, flying a Vickers Swift at 737·3 m.p.h. Then on October 3 James B. Verdin, flying a Douglas Skyray of the U.S. Navy, captured the record with a flight of 753·4 m.p.h. on the shore of S. California's Salton Sea.*

β Tauri which it approaches during its westward movement. Saturn, a morning star, rises 45 minutes before the sun on November 1 and cannot be seen but on November 15 and 30 it rises at 5h 15m and 4h 30m respectively, and is visible for some time before sunrise close to the 4th magnitude star κ Virginis.

A number of fine constellations are visible at convenient hours during the month, such as Orion, Taurus, including its beautiful cluster—the Pleiades, Gemini, and others. The Great Nebula in Orion can be easily seen in the middle star of the sword with slight optical aid and on a clear night it is visible to the naked eye as a haziness. This great cloud of cosmic dust is about 600 light-years distant and is a wonderful sight when viewed through a moderate sized telescope. On November 21d 1h 12·8m the 3rd magnitude star η Tauri is occulted by the moon and reappears at 1h 38m.

**Growing the Cold Virus outside the Human Body**

Nearly all the deadliest infections have fallen before the concerted onslaught of modern science, poliomyelitis being the most notable exception. The common cold too has defied all attempts to bring it under control. Year in and year out man grimly bears his common cold cross of blocked nasal passages and hacking cough.

There can be no doubt that much of the impotence of medical science in its battle against the cold has been its inability to culture the elusive cold virus. Scientists have failed to grow the cold virus on any medium except human tissue in living form. Incubating eggs, twenty different varieties of laboratory animals, even living cultures of human nasal epithelium —all of these the cold virus has found inadequate. It is quite true that the cold virus will infect the chimpanzee, but this creature is in fact a much more impracticable experimental animal than man himself.

Now Dr. C. H. Andrewes and his coworkers at the Common Cold Research Unit, Salisbury, have succeeded in preparing a dish which is to the cold virus's taste.

What the cold virus thrives on, they have found, is a culture of lung tissue from the human embryo. The medium is so congenial that Dr. Andrewes has been able to pass the virus from culture plate to culture plate ten times over. Yet after all that long separation from the human body it does not lose its infectiousness. In 10% of human volunteers exposed to it the artificially cultivated virus brings on all the sniffles and sneezes of the typical cold. This may seem a low infectivity rate, but actually it compares quite favourably with the 30–50% 'takes' obtained with infectious throat washings from persons with colds.

Now that science has grown the cold virus in the 'test tube', so to speak, it may be able to get on with the job of easing man's burden of seasonal—and unseasonal —colds. Now that the cold virus can be grown artificially, the hope of developing an anti-cold vaccine is less remote than it was; but even if a vaccine is slow to materialise, studies on the behaviour and susceptibilities of the isolated cold virus should provide clues for the more effective avoidance of infection and the more efficacious treatment of the disease once it sets in. Readers interested in more details should consult the paper by Dr. Andrewes and his colleagues published in *The Lancet* (1953, Vol. II, p. 546).

**Conservation of Raw Materials: Sources of Information**

Research organisations in Great Britain and the principal European countries are working on the problems of conserving such raw materials as metals, fuels, chemicals and textiles which are scarce. The work being done includes the discovery of methods of economising in the use of the materials, the provision of adequate substitutes, the recovery of waste materials and the protection of materials liable to be attacked by corrosion or decay. It is not always easy for an inquirer on these subjects to discover all the sources of information on the problem in which he is interested. Lists of sources on a wide range of subjects have now been collected by the Sub-committee for Co-operation in Scientific Research and Technical Development of the O.E.E.C. The information available covers work being done in Austria, France, Germany, Italy, the United Kingdom and Sweden.

Special lists have been prepared relevant to special aspects of the following items: building materials, cellulose, corrosion, fuels, glass, iron and steel, non-ferrous metals, ores, paper, plastics, rubber, sulphur, leather textiles, and wood. Two examples are the lists dealing respectively with wind power for electrical generation, and with protection of building materials from fungus and rust.

The lists can be consulted at, or borrowed from, the Technical Information and Documents Unit, D.S.I.R., at Cunard House, 15 Regent Street, London, S.W.1.

# THE BOOKSHELF

**An American in Europe: The Life of Sir Benjamin Thompson, Count Rumford** by Egon Larsen (*London, Rider & Co., 1953, 224 pp., 15s.*)

Rumford, during his lifetime, was renowned throughout the Western world. His name was a byword to the French soldier who spoke of an indifferent meal as one *à la Rumford*; his features were recognised by the poor of several capital cities; his work in pure and applied science was acclaimed by the learned societies of his day; and he was personally known to the heads of many sovereign states.

Yet, in spite of all this, both he and his work have been nearly forgotten. He barely receives mention in the histories of science, and he has been the subject of only one substantial biography. These facts make Mr. Larsen's book both welcome and necessary. It appears opportunely as this year is the second centenary of Rumford's birth.

The author has given a vivid account of Rumford's life and of much of his work. The story is of great interest not only because of the character and achievement of its subject, but also because of the picture it gives of some aspects of life in Europe in the late 18th and early 19th centuries. It can be recommended for these reasons both to the general reader and for inclusion in school and training college libraries.

This is a popular biography, and considered as such it is a satisfying book. The writer has been at pains to use a wide range of sources, including Ellis's great memoir written about eighty years ago, and also the researches of the late Mr. Allen French, an account of which is given in *General Gage's Informers*. He has, however, repeated some errors which a more careful study of primary sources would have corrected. For example, it is clear from a letter Rumford wrote to Sir Robert Keith that he *asked* for the post in Bavaria: it was not offered to him. Secondly, there *is* evidence that he tried to make contact with his relatives when he returned to America to fight for the British. Thirdly, his return to Bavaria in 1801 arose from anxiety about his position there in view of the new Elector's pro-French policy. These and other facts are important because they throw light upon Rumford's complex character.

The least satisfactory part of the book is the account of Rumford's scientific work. There is, of course, insufficient space in a work of this kind for a thorough treatment, but the author's description contains misconceptions about the nature and results of some of Rumford's researches. Although it is a fact that Rumford's experiments were more damaging to the caloric theory than any that had gone before, it is not true to say that his "categoric statements . . . dealt the deathblow to the theory of the 'igneous fluid'." Nor is it accurate to say that "he may be called the father of the vacuum (thermos) flask because he discovered that heat cannot travel through a vacuum". Furthermore, it is misleading to quote without comment Youman's over-enthusiastic advocacy of Rumford's claims as the founder of the dynamical theory of heat.

Judged as a whole, however, Mr. Larsen's book creates in the mind of the reader an undistorted picture of Rumford's life, and a true conception of his character.

The style of writing holds the interest; there are numerous illustrations—some highly entertaining—and there is a good

index. It is to be hoped that this book will help to arouse interest once more in a man who should be remembered for many reasons, but particularly because he was one of the apostles of applied science.

W. J. SPARROW

**Flying Saucers** by Donald H. Menzel (*London, Putnam & Co., 1953, 319 pp., 21s.*)

The 'flying saucer' scare of 1947 was not the first of its kind, but no previous epidemic of this type of mass hallucination ever spread so far; 1947 provided a proof that modern mass media of communication can spread rumours as fast as they can spread true facts. Another reason for the difference was that in 1947 few scientists gave public utterance to what they knew to be the true facts of the case. In addition, the general public seemed to be rather more gullible in 1947 than on previous occasions; their smattering of knowledge about aeronautical progress seems to have been associated with an attitude of mind which provided fertile ground for pseudo-scientific belief in space travel, and even for the remote idea that the saucers were interplanetary space ships. Culmination of the affair was the report—a complete hoax which, however, many found quite plausible—that a wrecked saucer made of some unearthly metal had been found, and that this contained bodies of dwarf astronauts from Venus—described as "midgets wearing 1890 clothes" made of some untearable fabric!

There were, of course, some *real* flying saucers that gave rise to the fantastic rumours. As the author of this book says, these were as real as rainbows. Dr. Menzel, astrophysics professor at Harvard, here provides full explanations of the different types of optical tricks which the atmosphere and its contents can play on human eyes and describes the optical phenomena which account for the flying saucers of 1947. His account of these matters is excellent, though he is far more entertaining when he is disposing of the various fanciful interpretations which people gave of those phenomena. He shoots to pieces the American book *Behind the Flying Saucers*, which was serialised in Britain and which did so much to propagate the hoax about the midgets from Venus.

**The Extra Pharmacopoeia, Vol. I.** (*London, The Pharmaceutical Press, 23rd Edition, 1952, 1352 pp., 55s.*)

THE complete 'Martindale', as the Extra Pharmacopoeia is familiarly known, is published in two volumes, and here we have the long-awaited post-war edition of Vol. I which describes the properties and uses of drugs. The previous edition of this book appeared in 1941, a volume of some 1,289 pages which in itself represented no mean feat of compression. The enormous progress made during the past ten years in the field of therapeutics has produced a whole host of new drugs and presented the compilers of the present work with a truly formidable undertaking when they came to sift the material available for inclusion. There is no question that this has been done well. The new volume retains the same style as its predecessor, and although the number of pages is only slightly greater the million-word text is a third as long again. This has been made possible by the use of a smaller type face and a larger page area, a layout which many users will no doubt find more attractive.

In the last edition Penicillin was disposed of in half a page; now, it and its kindred antibiotics occupy nearly a hundred. Among the many new drugs which appear for the first time we find the family of antihistamines, *d*-tubocurarine, the active principle of curare, with its synthetic analogues now extensively used as adjuncts in anaesthesia to produce muscular relaxation during operations. Several pages are devoted to cyanocobalamin, better known as vitamin $B_{12}$. The newer synthetic analgesics, of which Pethidine and Amidone are examples, are dealt with, and important drugs not generally available in this country (such as Cortisone) are also mentioned.

The section dealing with blood has been greatly enlarged to include the latest advances in transfusion practice and blood grouping, and the synthetic plasma substitutes, dextran and polyvinylpyrrolidine. On the purely pharmaceutical side we find the newer emulsifying agents described, and there is also a section dealing with the surgical haemostatics developed in recent years—gelatine foam, oxidised cellulose and calcium alginate.

A useful feature of the book are the references to antidotes where appropriate to overdoses of the more potent drugs.

There are 4000 abstracts of published work, three-quarters of which have been taken from the literature over the last ten years. There is a therapeutic and pharmacological index as well as an 82-page alphabetical index of 12,000 headings.

To say *The Extra Pharmacopoeia* is useful is an understatement; to the pharmacist it is indispensable, as well as to the many whose work fringes on pharmaceutical practice.

**Photo-Electric Multipliers** by S. Rodda (*London, Macdonald & Co., 1953, 180 pp., 22s. 6d.*)

This book deals in a practical fashion with the most sensitive detector of visible radiation that man has devised; as the author says, "The well-behaved photomultiplier tube can just detect the radiation falling on a 100-inch mirror from a candle 3000 miles away." The qualification necessary in this statement shows that the manufacture and use of these devices still lies in that fruitful no-man's-land between art and science. Mr. Rodda, an exponent of both, gives an interesting account of the fundamental principles involved and a concise history of the development of these tubes. He describes in some detail the leading commercial types and devotes three chapters to various applications, including that of the scintillation counter. The book will find a useful place on the shelves of the working chemist or physicist who wishes to get the best out of his instruments, while its style and treatment place it well within the grasp of the physics student.

C. G. A. H.

**Insects Indomitable.** By Evelyn Cheesman. (*London, G. Bell & Sons, 1952, 205 pp., 16 figs, 12s. 6d.*)

MISS CHEESMAN is an indomitable explorer and a good writer. This book is a potpourri of her experiences during her travels in New Guinea and the Pacific Islands, interlarded with odd gleanings from scientific literature. The result is charming and fascinating, completely personal—and entirely anthropomorphic in its approach. Perhaps such books produce budding entomologists from the ranks of the under-nine-year-olds, but even they today tend to revolt from the type of humanised insects which apparently appeal to Miss Cheesman. It is a pity, because she is a shrewd observer and a good field naturalist, that so many of her accounts of insect life are spoilt in this way.

One cannot help feeling that here is the material for a readable first-class account of little-known aspects of the insect life of the Eastern islands of the tropics, frittered away because of unnecessary sentimentality.

D. W. M.

**Teach Yourself Astronomy** by David S. Evans (*London, English University Press, 1953, 188 pp., 6s.*)

An introductory work on astronomy for only six shillings seems almost too good to be true, but it turns out to be both true and good—not only for the general reader, but as a first text-book for the young student. In his foreword Dr. Evans gives a warning that he has not "been at pains to let the reader down particularly lightly" in the matter of mental effort required in reading his book. The warning is justified in the sense that he has included the fundamentals of positional astronomy and navigation, and has used simple mathematics forms where necessary, but on the other hand his exposition is so lucid that the "Teach Yourself" part of the title remains apt. Certainly a reader possessing an elementary knowledge of mathematics including a little trigonometry will experience no difficulty whatever, and will gain from this book a very clear idea of his place in the Solar System if not in the Galaxy.

The approach is practical and observation is encouraged. Chapter VII is entitled "Get Yourself a Telescope" and is full of good advice, although the difficulty of mounting a small reflector is exaggerated: any enthusiast with ordinary hand tools can tackle a six-inch quite easily. The author has been liberal with his diagrams and sketches; the plates are not the old and rather too familiar friends so often found in books on this subject, but are instead mostly recent and of excellent quality. The star maps are rather small and not well arranged, which seems the more unfortunate as the notes on the constellations are so interesting—probably sufficiently

interesting to encourage the purchase of a small star atlas (e.g. *Popular Star Atlas* by Gall and Inglis) or a set of charts. The appendices, which include a short dictionary of astronomical terms, comprise a collection of information that will be invaluable to most readers, and the book closes with a most unusual feature—an adequate index. The volume is strongly recommended. G. F. WEST

**The Silent World** by J.-Y. Cousteau with Frederic Dumas (*London, Hamish Hamilton, 1953, 341 pp., 18s.*)

Goggle or mask diving has captured the imagination of the public, and films and television and the general 'mystery' of underwater life have added interest to the subject. So far as printed description of this type of diving goes, Cousteau's book is the most outstanding.

Captain Jacques-Yves Cousteau founded the French Navy's Undersea Research Group immediately after the war, but he first began goggle diving in the 1930s. He is famous for developing what is now known as the aqualung equipment, comprising oxygen cylinders strapped on to the back and a controller breathing mask. Goggles, of course, were a diving device known centuries ago to the Polynesians and Japanese; to the 16th-century Mediterranean coral divers; and rediscovered (as Cousteau puts it) "about every decade in the last 50 years". The naked human eye is almost blind underwater, but one can see clearly through watertight spectacles.

With this equipment, Cousteau and his companions Dumas, Tailleuz and poor Largé (who was drowned at the end of nearly a 400-ft. dive) performed prodigious feats of undersea exploration, during which they collected data of interest to physicists, biologists, geologists and archaeologists. Cousteau naturally leaves to his reader's imagination the naval and military application of this diving technique.

Apart from a most lucidly written text, this book is equally remarkable for its illustrations. The author has designed a pressurised Rolleiflex camera with which he has taken eight films, some of them in colour.

To penetrate the blackness of deep underwater in order to photograph the colour of the sea bed, a flash of over 40 million lumens was used to illuminate an area with a radius of 15 ft.—"a light that, except perhaps for the inner burst of an atomic bomb, had never been unloaded in such a small area".

Space does not admit of detailing the many thrilling experiences that Cousteau and his men simultaneously enjoyed and detested. What is probably more important to readers of DISCOVERY is the new data that they are bringing to the scientific world. P. V. D.

**The Price of Gamow's Book**

Gamow's new book, *Mr. Tompkins Learns the Facts of Life*, costs 12*s.* 6*d.* The price was incorrectly given at the head of Prof. P. T. Thomas's review in last month's issue.

# LETTERS TO THE EDITOR

**The Efficiency of Electric Space Heating**

Sir: On the first page of your July issue the statement occurs that in the conversion of electricity into heat by means of an electric fire only about 1% of the heat in the coal is made available for space heating. The figure of 1% is very wide of the mark.

The Report of the British Electricity Authority for the year ending March 31, 1953, gives the average efficiency of generating stations in this country as 22·72%. This figure represents the ratio of electric energy sent out from generating stations to the energy in the coal supplied to them. During the same year the loss of energy in transmission and distribution was 10·8%. So the average efficiency of electricity supplies taken as the ratio of electrical energy supplied to consumers, to the energy burnt in generating stations, was 20·26%.

The efficiency of supplies to domestic consumers is inevitably a little lower than the average for the whole country, because of additional losses in low-tension distribution, which do not occur when large industrial consumers take their supplies at a high voltage. If it be assumed that the additional distribution loss raises the above-mentioned figure of 10·8% to 14%, the domestic consumer obtains in the form of electricity a quantity of energy equal to 19·5% of the energy contained in the coal burnt to generate it. In an electric fire, conversion of this energy into heat is complete; in other words, the efficiency of an electric fire is 100%, taken as the ratio of the heat energy given out by it to the electrical energy supplied to it. These figures show that the 1% efficiency given in your July number should be nearer 20%.

This figures applies to the average of the whole country for the year ending March, 1953. Extensions of domestic heating will have to be met by the provision of more modern and more efficient generating stations. At the present moment the best installations in this country have an efficiency of 30%, which figure is to be compared with the 22·72% mentioned above. Thirty per cent will be met infrequently and the average generating efficiency for all new plant taken over a year's working is likely to be about 28% in the near future. Allowing for losses in transmission and distribution, the result will be that the above-mentioned 19·5% will be approximately 24% efficiency for any space heating met in future by additions to the country's generating resources.

Yours faithfully,
REGINALD O. KAPP.

*We are pleased to print Professor Kapp's correction of this error, which we copied direct from a document that was prepared by a highly respected authority on power for Unesco and widely distributed by that organisation. We are grateful to all the other readers who wrote pointing out this mistake, and in particular to Mr. Z. M. Reid who first drew our attention to it.—Editor.*

**The Principles of Priestman's Engine**

Sir: I have read with interest the article entitled "Diesel: What's In a Name?" in the August issue of DISCOVERY (pp. 236-7) and am glad to note therein that the part played by my late uncle, W. D. Priestman in developing the paraffin/oil engine some 65 years ago has not, as often previously, been overlooked.

There are, however, two comments I would venture to make.

The basis of the Priestman engine as actually constructed was not to compress the air alone first and then to inject the hydrocarbon fuel, as your article suggests. What happened was that a jet of oil controlled by the engine governor and a current of air were mixed together under light pressure through a spray nozzle. The mixture so formed was then received into a jacketed chamber and vaporised by the heat of the exhaust. During the suction stroke additional air, also regulated by the governor, was drawn through the same chamber along with the oil vapour into the cylinder, compressed and fired, as you say, by a spark. This, after much experimenting, was the method ultimately used.

My second point is that from 1888 onwards hundreds of Priestman oil engines were sold and the engine had fully established itself as a new form of prime mover before the advent of the Hornsby-Akroyd engine. The Priestman engine only became commercially unsuccessful when it was driven off the market by one which could be more cheaply made.

Yours faithfully,
S. H. PRIESTMAN.

*Priestman Brothers Ltd.,*
*Holderness Engineering Works, Hull.*

esigned a
ith which
f them in

of deep
graph the
f over 40
minate an
ight that,
rst of an
loaded in

ailing the
Cousteau
oyed and
re impor-
the new
scientific
P. V. D.

*Tompkins*
12*s.* 6*d.*
en at the
review in

p. 236–7)
t the part
Priestman
gine some
reviously,

mments I

engine as
compress
nject the
icle sug-
a jet of
rnor and
her under
zzle. The
ived into
ed by the
e suction
ulated by
ough the
il vapour
nd fired,
ter much
ltimately

om 1888
man oil
had fully
of prime
Hornsby-
n engine
uccessful
et by one
ade.

STMAN.

*d.*,
*ks, Hull.*

BOO

Scien
Bar
288

It is a
today
very
know
proof
extra
integr
until
Barbe
coine
Sir J.
Colleg
such
learni

As
on th
the m
could
within
an am
It was
produ
was ac
5000
for the
hamm
Mode
than is
forwar
have
ration

*Phone*

**BOOKSHELF**—*continued from p. 360*

**Science and the Social Order** by Bernard Barber (*London, Allen & Unwin, 1953; 288 pp., 20s.*)

It is a commonplace to say that our lives today are conditioned by science. The very word now connotes a triple idea of knowledge, technique and organisation—proof in itself that science is not something extraneous to society, but in fact an integral part of our ordered existence. Not until the nineteenth century, as Bernard Barber points out, was the term *scientist* coined by Dr. Whewell, a predecessor of Sir J. J. Thompson as Master of Trinity College, Cambridge. Before that, no such distinction marked this branch of learning.

As Dr. Barber emphasises, in a chapter on the historical development of science, the medieval world, whose best thinkers could reason clearly and cogently enough within the limits set by Scholasticism, has an amazing list of inventions to its credit. It was social and economic factors that produced these, for the shortage of labour was acute, and "as early as 1086 there were 5000 watermills in England alone, used for the fulling of cloth, for trip- and forge-hammers, and for pumping and winding". Modern science has a longer ancestry than is commonly thought; its great leaps forward, from the 16th century onwards, have been due to the combination of rationalism and empiricism.

To this must be added the spirit of individualism, the decay of which in totalitarian States becomes such a grave threat in the long run. Now that governments must both foster and make use of scientific research, the problem arises in the free world of ensuring that personal initiative shall not be cramped in an atmosphere of dead routine, and investigations in 'pure' science made subservient to strictly practical ends. Dr. Barber claims that in the United States this danger is largely met by the appropriate types of social organisation, e.g. the university, industry and government, which "provide adequate mechanisms for establishing and controlling the requisite kinds of motivation for scientific work". Four of his eleven chapters are devoted to the position and role of the scientist in these considerable departments of American life, and it appears that, in general, scientists in America are reasonably well satisfied with their standing and their opportunities. Some of them, indeed, tend to assume a greater degree of responsibility than is warranted, and to speak as though the settlement of political issues could rest with them. The author is not one of these. Recalling Clemenceau's remark that war is much too important to be left to the military, he declares that similarly science and its consequences are much too important to be left to the scientists. Altogether this is a refreshing and most informative book.

E. N. PARKER


# Classified Advertisements

ALL *correspondence relating to advertisements should be addressed to:*

**ALDRIDGE PRESS LTD.**
**15 Charterhouse St., London, E.C.1.**
Telephone **HOLborn 8655.**

*Rates are 2s. 6d. a line; titles 5s. a line. No extra charge for box numbers. Sales are 16,000 monthly, with an estimated readership of over 60,000.*

**LECTURES AND COURSES**

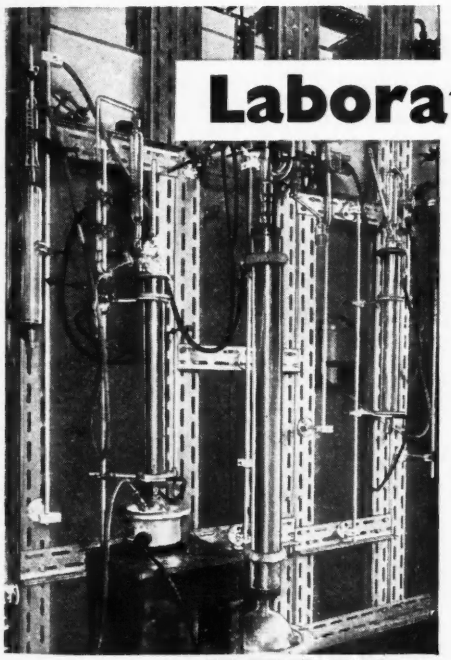
FARADAY HOUSE
ELECTRICAL ENGINEERING
66 Southampton Row, London, W.C.1

A FOUR-YEAR full-time course, which includes practical training with mechanical and electrical engineering firms, for the Faraday House Diploma which is accepted for Graduate Membership of the I.E.E.

For particulars apply Dept. E.

**MISCELLANEOUS**

BOOKBINDING, EXPERT WORKMANSHIP, prompt delivery at moderate prices. Maxsons Bookbinding Co. Ltd., Maxwell House, 242 Marylebone Road, London, N.W.1. (Tel: AMBassador 3421.)



# Laboratory Staging

**EVERYWHERE DEXION** is cutting equipment costs. This laboratory staging, for example, is made entirely from this remarkably versatile material. Storage racks, trolleys, conveyors and a hundred other structures can be made — exactly to your own needs, in a few hours, without waste, by unskilled labour on the spot. You save time, space and money. That's why Dexion is used by firms like I.C.I., D.C.L., Monsanto, May and Baker — and 20,000 others.

***Build your own equipment with***

**DEXION**
SLOTTED ANGLE

★ **Can be used over and over again**
★ *No drawings required—rough sketches are good enough*
*No drilling, welding, measuring or painting. No scrap*
★ **Just cut it and bolt it, that's all!**

*Write or telephone for illustrated booklet CH41.*

*Phone : Regent 4841* **DEXION** LTD., TRIUMPH HOUSE, 189 REGENT ST., LONDON, W.1
T.A.4559

# Classified Advertisements

## OFFICIAL APPOINTMENTS

EXPERIMENTAL OFFICERS AND ASSISTANT EXPERIMENTAL OFFICERS in various Government Departments. The Civil Service Commissioners invite applications for pensionable posts. Applications may be accepted up to 31 December, 1953, but an earlier closing date may be announced either for the competition as a whole or in one or more subjects.

The posts are divided between following main groups and subjects: (*a*) Mathematical and Physical Sciences, (*b*) Chemistry and Metallurgy, (*c*) Biological Sciences, (*d*) Engineering subjects and (*e*) Miscellaneous (including e.g. Geology, Library and Technical Information Services).

*Age Limits:* For Experimental Officers, at least 26 and under 31 on 31 December, 1953; for Assistant Experimental Officers at least 18 and under 28 on 31 December, 1953. Extension for regular service in H.M. Forces.

Candidates must have at least one of a number of specified qualifications. Examples are Higher School Certificate, General Certificate of Education, Scottish Leaving Certificate, Scottish Universities Preliminary Examination, Northern Ireland Senior Certificate (all in appropriate subjects and at appropriate levels), Higher National Certificate, University degree. Candidates taking their examinations in 1953 may be admitted. Candidates without such qualifications may be admitted exceptionally on evidence of suitable experience. In general a higher standard of qualification will be looked for in the older candidates than in the younger ones.

Inclusive London salary scales:

Experimental Officer
£681–£838(men); £586–£707 (women).
Assistant Experimental Officer
£274–£607 (men); £274–£511 (women).

Starting pay according to age up to 26. At 18, £274; at 26, £495 (men) £467 (women). Somewhat lower in provinces.

Further particulars and application forms from Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting No. S94–95/53. Completed application forms should be returned as soon as possible.

---

ASSISTANT (SCIENTIFIC): The Civil Service Commissioners invite applications for pensionable posts. Applications may be accepted up to 31 December, 1953, but an earlier closing date may be announced either for the competition as a whole or in one or more subjects.

Age at least 17½ and under 26 years of age on 1 January, 1953, with extension for regular service in H.M. Forces, but candidates over 26 with specialised experience may be admitted.

Candidates must produce evidence of having reached a prescribed standard of education, particularly in a science subject and of thorough experience in the duties of the class gained by service in a Government Department or other civilian scientific establishment or in technical branches of the Forces, covering a minimum of two years in one of the following groups of scientific subjects:

(i) Engineering and physical sciences.
(ii) Chemistry, bio-chemistry and metallurgy.
(iii) Biological sciences.
(iv) General (including geology, meteorology, general work ranging over two or more groups (i) to (iii) and highly skilled work in laboratory crafts such as glass-blowing).

Salary according to age up to 25: £236 at 18 to £363 (men) or £330 (women) at 25 to £500 (men) or £417 (women); somewhat less in provinces. Opportunities for promotion.

Further particulars and application forms from Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting No. S.59/53. Application forms should be returned as soon as possible.

## APPOINTMENTS VACANT

TECHNICAL ASSISTANTS are required by The Distillers Co. Ltd. in their Research and Development Department, Epsom, Surrey, for plant work on chemical processes. Age 27–31. Post will involve shift work. Candidates should be of Inter-B.Sc. standard and preferably have some experience. Apply: Staff Department, The Distillers Co. Ltd., 21 St. James's Square, London, S.W.1.

---

PHYSICAL METALLURGISTS: Vacancies for physical metallurgists in a fundamental research laboratory. Several year's research experience since graduation required. Interest in the nature of high temperature alloys and equilibrium diagram techniques an advantage for one post. Apply in writing to Personnel Officer, Associated Electrical Industries Limited, Research Laboratory, Aldermaston Court, Aldermaston, nr. Reading, Berks.

---

CHEMIST: A vacancy for a Chemist in the physical metallurgy section of a fundamental research laboratory. Good degree in chemistry and experience in experimental work required. Familiarity with vacuum apparatus, reactive materials or transitional metals an advantage. Apply in writing to Personnel Officer, Associated Electrical Industries Limited, Research Laboratory, Aldermaston Court, Aldermaston, nr. Reading, Berks.

---

CHEMISTS AND PHYSICISTS interested in joining a research team investigating fundamental problems associated with the hardening of Portland Cement are invited to apply for interview to the Controller, Cement & Concrete Association, Wexham Springs, Stoke Poges, Slough, Bucks. Suitable candidates, who should possess a good degree, will be offered varied and interesting work and a starting salary in the range £450–£800 p.a.

## APPOINTMENT WANTED

CHEMIST, INDIAN (29), M.Sc., D.Phil., wishing to migrate permanently seeks research job in industry, especially petroleum. Keen mind, good experimentalist. Any reasonable start. Contact Box No. D1514, Aldridge Press Ltd., 15 Charterhouse Street, London, E.C.1.

## SOCIETIES

THE BRITISH INTERPLANETARY SOCIETY
12 Bessborough Gardens,
London, S.W.1

MEMBERSHIP and Fellowship is open to all interested in rocket engineering, astronomy and space-flight.

Full particulars of membership, together with a free copy of the Society's Book List and programme of lectures in London, Birmingham and Manchester, will be sent on request.

## FOR SALE

XMAS GIFTS. Send 4*d.* for 16 pp. illustrated "NATURE-GIFTS" Catalogue. 5-year Diaries for Nat. Hist. records, 8*s.* 11*d.* Vasculums, 39*s.* 6*d.* Nestboxes, 10*s.* 9*d.* Bird Ringing Equipment Catalogue 3*d.* Dept. M, Greenrigg Works, Woodford Green, Essex.

**Classified Advertisements**—*contd. on p. 361*

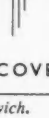
**PATENTS, TRADE MARKS AND DESIGNS**

CHARTERED PATENT AGENTS

**W. H. BECK & CO.**

Morley House
26-28 Holborn Viaduct
London, E.C.1. Telephone: Central 1611

We can supply



BINDING CASES Vol. XIII 1952
at short notice
Price 5*s.* including postage

DISCOVERY, JARROLD & SONS LTD, NORWICH

*Printed and Published in Great Britain by Jarrold & Sons Ltd., Norwich.* *Editorial Office: 244 High Holborn W.C.1*

, Alder-

emist in
on of a
. Good
ence in
miliarity
naterials
vantage.
Officer,
Limited,
rmaston
, Berks.

ested in
stigating
ed with
nent are
he Con-
ociation,
Slough,
should
offered
starting

ED

D.Phil.,
ly seeks
y petro-
entalist.
Box No.
Charter-

ETY

open to
neering,

hip, to-
Society's
tures in
chester,

16 pp.
talogue.
records,
stboxes,
nt Cata-
Works,

on p. 361

WICH